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# GEORGE R.

GEORGE the Second, by the Grace of God, King of *Great-Britain*, *France* and *Ireland*, Defender of the Faith, &c. To all to whom theſe Preſents ſhall come, Greeting. Whereas *James Buckland*, *James Waugh*, *John Ward*, *Thomas Longman*, and *Edward Dilly*, Citizens and Bookſellers of our City of *London*, have by their Petition humbly repreſented unto Us, that they have purchaſed the Copy-Right of the WHOLE WORKS of the late DOCTOR ISAAC WATTS, and that they are now printing and preparing for the Preſs, new Editions with Improvements, of ſeveral of the ſeparate Pieces of the ſaid Doctor *Iſaac Watts*. They have therefore moſt humbly prayed Us, that We would be graciouſly pleaſed to grant them our Royal Licence and Protection for the ſole printing, publiſhing, and vending the ſaid Works, in as ample Manner and Form as has been done in Caſes of the like Nature; We being willing to give all due Encouragement to Works of this Nature, which may be of publick Uſe and Benefit, are graciouſly pleaſed to condeſcend to their Requeſt, and do therefore by theſe Preſents, as far as may be agreeable to the Statute in that Behalf made and provided, grant unto them, the ſaid *James Buckland*, *James Waugh*, *John Ward*, *Thomas Longman*, and *Edward Dilly*, their Executors, Adminiſtrators, and Aſſigns, our Royal Privilege and Licence, for the ſole printing, publiſhing, and vending the ſaid Works for the Term of fourteen Years, to be computed from the Date hereof, ſtrictly forbidding and prohibiting all our Subjects within our Kingdoms and Dominions, to reprint, abridge, or tranſlate the ſame, either in the like, or any other Volume or Volumes whatſoever, or to import, buy, vend, utter, or diſtribute any Copies thereof reprinted beyond the Seas, during the aforeſaid Term of fourteen Years, without the Conſent and Approbation of the ſaid *James Buckland*, *James Waugh*, *John Ward*, *Thomas Longman*, and *Edward Dilly*, their Executors, Adminiſtrators and Aſſigns, by Writing under their Hands and Seals firſt had and obtained, as they and every of them offending herein, will anſwer the contrary at their Peril, whereof the Commiſſioners and other Officers of our Cuſtoms, the Maſter, Wardens, and Company of *Stationers* of our City of *London*, and all other our Officers and Miniſters, whom it may concern, are to take Notice, that due Obedience be rendered to our Pleaſure herein ſignified.

Given at our Court at St. *James*'s the Twenty Firſt Day of *March*, 1758. in the Thirty Firſt Year of Our Reign.

By His Majeſty's Command.

W. PITT.

# *The Knowledge of the* HEAVENS *and the* EARTH *made Eaſy:*

OR, THE

# Firſt Principles

OF

# ASTRONOMY

AND

# GEOGRAPHY

Explain'd by the Uſe of GLOBES and MAPS.

WITH A

Solution of the Common PROBLEMS by a *plain Scale and Compaſſes*, as well as by the *Globe*.

WRITTEN ſeveral Years ſince for the USE of LEARNERS.

---

*By* I. WATTS, *D. D.*

---

The SIXTH EDITION, Corrected.

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Pſal. viii. 3. — *I conſider thy Heavens, the Work of thy Fingers, the Moon and the Stars which thou haſt ordained.*

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To my Learned Friend

# Mr. *JOHN EAMES*,

Fellow of the Royal Society.

*Dear Sir*,

IT would be mere trifling to ſay any thing to you of the Excellency and great Advantage of thoſe *Sciences*, whoſe firſt Rudiments I have here drawn up. Your large Acquaintance with theſe Matters hath given you a juſt Reliſh of the Pleaſure of them, and well informed you of their ſolid uſe. But, perhaps, it is neceſſary to excuſe my ſelf to the World, if I publiſh ſome of the Fruits of my former Studies on ſuch Subjects as theſe. I would therefore willingly have the unlearned Part of Mankind apprized of the Neceſſity and general Uſe of this ſort of Learning; and that not only to Civil, but to Sacred Purpoſes.

If you, Sir, would pleaſe to take upon you this Service, you would make it appear with rich Advantage how far the Knowledge of Things Human and Divine are influenced and improved by theſe Studies.

You can tell the World, that it is the Knowledge of this *Globe of Earth* on which we tread, and of thoſe *Heavenly Bodies* which ſeem to roll around us, that hath been wrought up into theſe two kindred Sciences, *Geography* and *Aſtronomy*. And there is not a Son or Daughter of *Adam* but has ſome Concern in both of them, though they may not know it in a learned way.

This *Earth* is given us for an Habitation: It is the place of preſent Reſidence for all our Fellow-mortals: Nor is it poſſible that there ſhould be any Commerce maintained with thoſe who dwell at a Diſtance, without ſome Acquaintance with the different Tracts of Land, and the Rivers or Seas that divide the Regions of the Earth.

The *Heavenly Bodies*, which are high over our Heads, meaſure out our Days and Years, our *Life* and *Time*, by their various Revolutions. Now *Life* and *Time* are ſome of the deareſt things we have, and it is of important Concern to diſtinguiſh the *Hours* as they paſs away, that proper Seaſons may be choſen and adapted for every Buſineſs.

You know, Sir, that thoſe neceſſary and uſeful Inſtruments, *Clocks*, *Watches* and *Dials*, owe their Origin to the Obſervations of the Heavens: The Computation of *Months* and *Years* had been for ever impracticable without ſome careful Notice of the various Situations and Appearances of thoſe ſhining Worlds above us.

I ſhall be told, perhaps, that theſe are not my ſpecial Province. It is the Knowledge of God, the Advancement of Religion, and Converſe with the Scriptures, are the peculiar Studies which Providence has aſſigned me. I know it, and I adore the Divine Favour. But I am free and zealous to declare, that without commencing ſome Acquaintance with theſe Mathematical Sciences, I could never arrive at ſo clear a Conception of many things delivered in the *Scriptures*; nor could I raiſe my Ideas of *God the Creator* to ſo high a Pitch: And I am well aſſured that many of the ſacred Function will join with me and ſupport this Aſſertion from their own Experience.

If we look down to the *Earth*, it is the Theatre on which all the grand Affairs recorded in the Bible have been tranſacted. How is it poſſible that we ſhould trace the Wandrings of *Abraham* that great Patriarch, and the various Toils and Travels of *Jacob*, and the *Seed of Iſrael* in ſucceſſive Ages, without ſome *Geographical* Knowledge of thoſe Countries? How can our Meditations follow the *Bleſſed Apoſtles* in their laborious Journies through *Europe* and *Aſia*, their Voyages, their Perils, their Shipwrecks, and the Fatigues they endured for the Sake of the Goſpel; unleſs we are inſtructed by *Maps* and *Tables*, wherein thoſe Regions are copied out in a narrow Compaſs, and exhibited in one View to the Eye?

If we look upward with *David* to the Worlds above us, *we conſider the Heavens as the Work of the Finger of God, and the Moon and the Stars which he hath ordained.* What amazing Glories diſcover themſelves to our Sight? What Wonders of Wiſdom are ſeen in the exact Regularity of their Revolutions?

Nor was there ever any thing that has contributed to enlarge my Apprehenſions of the immenſe Power of God, the Magnificence of his Creation, and his own tranſcendent Grandeur, ſo much as that little Portion of *Aſtronomy* which I have been able to attain. And I would not only recommend it to *young Students* for the ſame Purpoſes, but I would perſuade *all Mankind* (if it were poſſible) to gain ſome Degrees of Acquaintance with the Vaſtneſs, the Diſtances, and the Motions of the Planetary Worlds on the ſame Account. It gives an unknown Enlargement to the Underſtanding, and affords a divine Entertainment to the Soul and its better Powers. With what Pleaſure and rich Profit would Men ſurvey thoſe aſtoniſhing *Spaces* in which the Planets revolve, the Hugeneſs of their *Bulk*, and the almoſt incredible Swiftneſs of their *Motions?* And yet all theſe governed and adjuſted by ſuch unerring Rules, that they never miſtake their Way, nor loſe a Minute of their Time, nor change their appointed Circuits in ſeveral thouſands of Years! When we muſe on theſe things we may loſe our ſelves in holy Wonder, and cry out with the Pſalmiſt, *Lord what is Man that thou art mindful of him, and the Son of Man that thou ſhouldeſt viſit him?*

It was chiefly in the younger Part of my Life indeed that theſe Studies were my Entertertainment; and being deſired both at that time, as well as ſince, upon ſome Occaſions, to lead ſome young Friends into the Knowledge of the firſt Principles of *Geography* and *Aſtronomy*, I found no Treatiſe on thoſe Subjects written in ſo very plain and comprehenſive a Manner as to anſwer my Wiſhes: Upon this Account I drew up the following Papers, and ſet every thing in that Light in which it appeared moſt obvious and eaſy to me.

I have joined the *general Part* of theſe two Sciences together: What belongs particularly to each of them is caſt into diſtinct Sections. And I wiſh, Sir, you would preſent the World with the *Special Part of Aſtronomy* drawn up for the Uſe of Learners in the moſt plain and eaſy Method, to render this Work more complete.

Moſt of the Authors, which I peruſed in thoſe Days when I wrote many Parts of this Book, were of older Date: And therefore the Calculations and Numbers which I borrowed from their *Aſtronomical Tables*, cannot be ſo exact as thoſe with which ſome later Writers have furniſhed us: For this Reaſon the Account of the *Sun's Place* in the Ecliptick, the *Declination* and *Right Aſcenſion* of the *Sun* and the *Stars* in ſome Parts of the Book, eſpecially in the Solution of ſome of the *Problems* in the 20th Section, may perhaps need a little Correction; though I hope the *Theorems* will appear true in the Speculation, and the *Problems* ſo regular and ſucceſsful in the Practice as is ſufficient for a Learner. However, to apply ſome Remedy to this Inconvenience, there are added at the End of the Book ſome later *Tables*, which are formed according to the celebrated Mr. *Flamſtead's* Obſervations.

I have exhibited near forty *Problems* to be practiſed on the Globe, and thirty-five more of various kinds, to be performed by manual Operation with the Aid of ſome *Geometrical* Practices. These were very ſenſible Allurements to my younger Enquiries into theſe Subjects, and I hope they may attain the ſame Effect upon ſome of my Readers.

It was my Opinion that it would be a very delightful Way of learning the *Doctrine* and *Uſes of the Sphere*, to have them explained by a Variety of *Figures* or *Diagrams*; this is certainly much wanting in moſt Authors that I have peruſed. I have therefore drawn thirty *Figures* with my own Hand, in order to render the Deſcription of every thing more intelligible.

I have endeavoured to entertain younger Minds, and entice them to theſe Studies, by all thoſe eaſy and agreeable Operations relating both to the *Earth* and the *Heavens*, which probably may tempt them on to the higher Speculations of the great Sir *Iſaac Newton* and his Followers on this Subject.

Yet there ſhould be a due Limit ſet to theſe Inquiries too, according to the different Employments of Life to which we are called: For it is poſſible a Genius of active Curioſity may waſte too many Hours in the more abſtruſe Parts of their Subjects which God and his Country demand to be applied to the Studies of the *Law*, *Phyſick*, or *Divinity*; to Merchandize or Mechanical Operations.

If I had followed the Conduct of mere Inclination, perhaps I ſhould have laid out more of my ſerene Hours in Speculations which are ſo alluring: And then indeed I might have performed what I have here attempted in a Manner more anſwerable to my Deſign, and left leſs for the Criticks to cenſure, and my Friends to forgive. But ſuch as it is, I put it intirely, *Sir*, into your Hands to review and alter whatſoever you pleaſe, and make it anſwerable to that Idea which I have formed of your Skill. Then if you ſhall think fit to preſent it to the World, I perſuade my ſelf I ſhall not be utterly diſappointed in the Views I had in putting theſe Papers together, many of which have lien by me in Silence above twenty Years.

Farewel, *Dear Sir*, and forgive the Trouble that you have partly devolved on your ſelf by the too favourable Opinion you have conceived both of theſe Sheets and of the Writer of them, who takes a Pleaſure to tell the World that he is, with great Sincerity,

*SIR*,

*Your moſt obedient Servant*,

Theobalds in
Hertfordſhire,
June 11. 1725.

I. WATTS.

# TO THE

# READER.

*I Think my ſelf obliged, in Juſtice to the ingenious Author as well as the Publick, to aſſure them that the Alterations I have ventured to make in the Reviſal of this Work, are but few and ſmall. The ſame Perſpicuity of Thought and Eaſe of Expreſſion which diſtinguiſh his other Works running through the whole of this, I don't queſtion but the World will meet with equal Pleaſure and Satisfaction in the Peruſal.*

Auguſt 20.
1725.

JOHN EAMES.

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## To the Bookbinder.

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# THE FIRST PRINCIPLES OF Geography and Aſtronomy.

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## SECT. I.

## *Of the* SPHERES *or* GLOBES *of the* HEAVEN *and* EARTH.

THERE is nothing gives us a more eaſy or ſpeedy Acquaintance with the *Earth* and the *viſible Heavens* than the Repreſentation of them on a *Globe* or *Sphere*; becauſe hereby we have the moſt natural Image of them ſet before our Eyes.

The *Terreſtrial Globe* repreſents the Earth with its ſeveral Lands, Seas, Rivers, Iſlands, *&c.* The *Celeſtial Sphere* or *Globe* repreſents the Heavens and Stars.

Several *Points* and *Circles* are either marked or deſcribed on theſe *Spheres* or *Globes*, or are repreſented by the Braſs and Wooden

Work about them, to exhibit the *Places* and the *Motions* of the Sun, Moon or Stars, the *Situation* of the ſeveral Parts of the Earth, together with the Relation that all theſe bear to each other.

The *Earthly Globe*, with the *Lines* and *Signs* and *Points* that are uſually marked upon it, is ſufficient to inform the Reader of almoſt every thing that I ſhall mention here, even with Regard to the *Heavens*, the *Sun* and the *Planets*; unleſs he has a Mind to be particularly acquainted with the *fixed Stars*, and the ſeveral Uſes of them; then indeed a *Celeſtial Globe* is moſt convenient to be added to it.

*Note* 1ſt, Half the Globe is called a *Hemiſphere*; and thus the whole Globe or Sphere of the Heavens, or of the Earth, may be repreſented on a Flat or Plane in *two Hemiſpheres*, as in the common *Maps* of the Earth, or in *Draughts* or *Deſcriptions* of the Heavens and Stars.

Becauſe *Globes* are not always at Hand, the ſeveral *Points* and *Circles*, together with their Properties, ſhall be ſo deſcribed in this Diſcourſe as to lead the Reader into ſome general and imperfect Knowledge of theſe Things (as far as it may be done by a *Map* of the World, which is nothing elſe but a *Repreſentation of the Globe of Earth and Waters on two Flat or*

*Plain Surfaces*;) or at leaſt I ſhall ſo expreſs theſe Matters, that a Map will aſſiſt him to keep them in Remembrance, if he has been firſt a little acquainted with the Globe itſelf.

*Note* 2d, Though the lateſt and beſt Aſtronomers have found that the *Sun* is fixt in or near the Centre of our World, and that the *Earth* moves round its own Axis once in twenty-four Hours with a *Circular Motion*, and round the Sun once in a Year with a *Progreſſive Motion*; yet to make theſe Things more eaſy and intelligible to thoſe that are unſkilful, we ſhall here ſuppoſe the *Sun* to move round the *Earth*, both with a *daily* and *yearly* Motion, as it appears to our Senſes; (*viz.*) daily going round the Earth, and yet every Day changing its Place a little in the Heavens, till in a Year's Time it returns to the ſame Place again.

## SECT. II.

### *Of the greater Circles.*

THE *Greater Circles* are ſuch as divide the Globe into two equal Parts, and are theſe four; (*viz.*) the *Horizon*, the *Meridian*, the *Equator*, and the *Ecliptick*.

1. The *Horizon* is a broad flat Circle, or the Wooden Frame in which the Globe

ſtands. Its upper Edge divides the *Globe* into the upper and lower Halves or *Hemiſpheres*, and repreſents the Line or Circle which divides between the upper and the lower Parts of the Earth and Heavens, and which is called the *Horizon*. This circle determines the *Riſing* or *Setting* of Sun or Stars, and diſtinguiſhes *Day* and *Night*.

When the Sun is in the Eaſt Part of the *Horizon*, it is *Riſing*. When in the Weſt Parts it is *Setting*. When it is above the *Horizon*, it is *Day*: When below it is *Night*.

Yet till the Sun be 18 Degrees below the *Horizon* it is uſually called *Twilight*; becauſe the Sun-Beams ſhooting upward are reflected down to us by the Atmoſphere after Sun-ſet or before Sun-riſe: And it is upon this Account that in in our Horizon at *London*, there is no perfect Night in the very Middle of Summer for two Months together, becauſe the Sun is not 18 Degrees below the Horizon.

The *Horizon* is diſtinguiſhed into the *Senſible* and the *Rational*. See *Fig.* 1.

The *Senſible Horizon* ſuppoſes the Spectator placed on *s* the Surface of the Earth or Water, and it reaches as far as the Eye can ſee. But the *Rational* or *True Horizon* ſuppoſes the Spectator placed in the Centre of the Earth *c*, and thus divides the Globes both of the Heavens and the Earth into Halves.

Suppoſe in *Figure* 1. the Circle *s d p e* is the Earth, *u b b n r g* the Heavens, *b s g* the Line making the Senſible Horizon, *b r* the Rational Horizon.

The *Senſible Horizon* on the Earth or Sea includes *a s o*, and it reaches but a very few Miles; for if a Man of ſix Feet high ſtood on a large Plain, or on the Surface of the Sea, at *s*, he could not ſee the Sea itſelf, or the Land, further than three Miles round.

Thus it appears that the *Senſible Horizon* on the Earth or Sea *a s o*, differs very much from the Extent of the *Real* or *Rational Horizon d s e*. But as to the Heavens where the fixt Stars are, the *Senſible Horizon b u g* ſcarce differs at all from the *Rational* Horizon *b u r*: For the Eye placed in the Centre of the Earth *c*, or on the Surface of it *s*, would find no evident Difference in the *Horizon* of the fixt Stars, becauſe they are at ſo immenſe a Diſtance, that in compariſon thereof half the Diameter of the Earth, that is *s c* or *g r* the Diſtance between the Surface and the Centre is of no Conſideration.

But let it be obſerved here, that the *Planets* are much nearer to the Earth than the *Fixt Stars* are: And therefore half the Diameter of the Earth, *i. e. s c* or *g r* is of ſome Conſideration in the Horizon of the *Planets*.

It may not therefore be improper to note in this Place, that ſuppoſe a *Planet* to be at *g*, if the Eye of the Spectator were on the Surface of the Earth at *s*, he would behold it as level with the *Horizon:* But if his Eye were at the Centre of the Earth at *c*, he would behold it raiſed ſeveral Degrees or Minutes above the *Horizon*, even the Quantity of the Angle *g c r*, or (which is all one) *s g c*.

Now the Difference between the Place where a *Planet* appears to a Spectator, placed on the *Centre* of the Earth, and to a Spectator placed on the *Surface*, is called the *Parallax* of that Planet at that time; and therefore the Difference between thoſe two Places *g* and *r*, or rather the Quantity of the Angle *g c r*, or *s g c*, is called its *Horizontal Parallax*. And this is of great uſe to adjuſt the real Diſtances, and conſequently the real Magnitudes of the ſeveral Planets. But this Doctrine of *Parallaxes* belongs rather to the ſecond or *ſpecial* Part of *Aſtronomy*.

II. The *Meridian* is a great Brazen Circle in which the Globe moves; it croſſes the *Horizon* at right Angles, and divides the Globe into the *Eaſtern* and *Weſtern* Hemiſpheres. It repreſents that Line or Circle in the Heaven which paſſes juſt over our Head, and cutting the *Horizon* in the *North* and *South* Points of it, comes juſt under our Feet on the oppoſite Side of the Globe.

This Circle ſhews when the Sun or Stars are juſt at *North* or *South*, and determines *Noon* or *Midnight*.

When the Sun is on the Meridian and above the Horizon to us in *Great Britain*, it is juſt in the *South*, and it is *Noon*. When it is on the Meridian and under the Horizon, it is juſt in the *North*, and it is *Midnight*.

*Note*, Whenſoever we move on the Earth, whether *Eaſt*, *Weſt*, *North*, or *South*, we change our Horizon both *Senſible* and *Rational*; for every Motion or Change of Place gives us a Hemiſphere of Sky or Heaven over our Head a little different from what it was; and we can ſee leſs on one Side of the Globe of the Earth and more on the other Side.

Whenſoever we move toward the *Eaſt* or *Weſt* we change our Meridian: But we do not change our Meridian if we move directly to the *North* or *South*.

Upon this Account the *Horizon* and *Meridian* are called *Changeable Circles*, and the Globe is made moveable within theſe Circles to repreſent this Changeableneſs, whereby every Place on the Earth may be brought under its proper Meridian, and be ſurrounded with its proper Horizon.

III. The *Equator* or *Equinoctial Line* croſſes the *Meridian* at right Angles, and divides the Globe into the *Northern* and *Southern* Hemiſpheres; and diſtinguiſhes the Sun's yearly Path into the *Summer* and *Winter* Half-Years. It repreſents in the Heavens that very Line or Circle which is the Path of the Sun in thoſe two Days in *Spring* and *Autumn* when the Days and Nights are of equal Length.

Among all the Circles of the Globe this is ſometimes eminently called *The Line*; and paſſing over it at Sea is called by Sailors *Croſſing the Line*.

*Note*, The Sun, Moon and Stars, with all the Frame of the Heavens, are ſuppoſed to be whirled round from Eaſt to Weſt every twenty-four Hours upon the Axis of the Equator, or (which is all one) in their ſeveral Paths parallel to the Equator. This is called their *Diurnal* or *Daily Motion*.

IV. The *Ecliptick Line* is the *Sun's Annual or Yearly Path*, cutting the Equinoctial in two oppoſite Points obliquely at the Angles of 23½ Degrees. On it are figured the Marks of the 12 Signs through which the Sun paſſes, (*viz.*) *Aries* the Ram ♈, *Taurus*, the Bull ♉, *Gemini* the Twins ♊, *Cancer* the Crab ♋, *Leo* the Lion ♌, *Virgo* the Virgin ♍, *Libra* the Balance ♎, *Scorpio* the Scorpion ♏, *Sagittarius* the Archer ♐, *Capricornus* the Sea-Goat ♑, *Aquarius* the Waterer ♒, *Piſces*, the Fiſhes ♓.

Theſe Signs are certain *Conſtellations* or Numbers of Stars which are reduced by the Fancy of Men for Diſtinction Sake into the Form of twelve Animals, and for the Uſe of the *Engliſh* Reader may be deſcribed thus.

*The* Ram, *the* Bull, *the heavenly* Twins,
*And next the* Crab, *the* Lion *ſhines*,
  *The* Virgin, *and the* Scales:
*The* Scorpion, Archer, *and* Sea-Goat,
*The* Man *that holds the* Water-pot,
  *And* Fiſh *with glittering Tails.*

Among theſe Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, are called *Northern*. But *Libra*, *Scorpio*, *Sagittarius*, *Capricornus*, *Aquarius*, *Piſces*, are *Southern*. *Capricorn*, *Aquarius*, *Piſces*, *Aries*, *Taurus*, *Gemini* are *Aſcending* Signs, becauſe they ſtand in Succeſſion *Northward*, or riſing gradually higher in our *European Hemiſphere*: But *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittarius*, are *Deſcending* Signs, for their Succeſſion tends lower toward our Horizon, or rather toward the *Southern* Hemiſphere.

Each of theſe Signs has 30 Degrees of the Ecliptick allotted to it. The Sun or any Planet is ſaid *to be in ſuch a Sign* when he is between our Eye and that Sign, or when he appears in that Part of the Heavens where thoſe Stars are of which the Sign is compoſed.

If it be enquired, How we can know the Place of the Sun among the Stars, ſince all the Stars near it are loſt in the Sun-Beams? It is anſwered, that we can ſee plainly what *Conſtellation* or what Stars are upon the Meridian at *Midnight*, and we know the Stars which are exactly oppoſite to them, and theſe muſt be upon the Meridian (very nearly) the ſame Day at *Noon*; and thereby we know that the Sun at Noon is in the Midſt of them. So that when you have a Globe at hand on which the Stars are delineated, you find on what Degree of any Sign the Sun is in on a given Day, and ſee the Stars around it.

The Sun is reckoned to go through almoſt one Sign every *Month* or 30 Days, and thus to finiſh the *Year* in 365 Days 5 Hours and 49 Minutes, *i. e.* near 6 Hours: So that the Sun may be ſuppoſed to move ſlowly as a Snail through almoſt one Degree of the *Ecliptick* Line every Day *from the Weſt to the Eaſt*, while it is whirled round together with the whole Frame of the Heavens *from Eaſt to Weſt*, in a Line parallel to the *Equator* in the Time of 24 Hours.

*Note*, We vulgarly call the *Sun's diurnal* or *daily Path* a *Parallel* to the Equator, though properly it is a *Spiral Line*, which the Sun is ever making all the Year long, gaining one Degree on the Ecliptick daily.

From what has been now ſaid it appears plainly, that the *Equinoctial* Line, or *Equator* itſelf, is the diurnal Path of the Sun about the 20th or 21ſt of *March* and the 23d of *September*, which are the two oppoſite Points where the *Ecliptick*, or Yearly Path of the Sun, cuts the *Equator*.

And theſe two Days are called the *Equinoctial Days*, when the Sun riſes and ſets at ſix a Clock all the World over, (*i. e.* where it riſes and ſets at all that Day ;) and the Day and Night are every where of equal Length: and indeed this is the true Reaſon why this Line is called the *Equator* or the *Equinoctial*.

It may not be improper in this Place to remark that thoſe 5 Hours and 49 Minutes, which the *Sun's Annual Revolution* requires above 365 Days, will in 4 Years Time amount to near a whole Day: Therefore every fourth Year has 366 Days in it, and is called the *Leap-Year*. *Note*, The ſuper-added Day in that Year is the 29th of *February* in *Great-Britain*.

It may be farther remarked alſo, that the odd 11 Minutes which in this Account are wanting yearly to make up a complete Day of 24 Hours, are accounted for in the *New Style* by leaving out a whole Day once in

133 or 134 Years *. And it is the Neglect of accounting for theſe odd Minutes in the *Old Style* above a thouſand Years backwards, that has made the Difference between the *Old Style* and the *New* to be at preſent *Eleven Days.*

*Note*, The *Zodiack* is fancied as a broad Belt ſpreading about 7 or 8 Degrees on each Side of the *Ecliptick*, ſo wide as to contain moſt of thoſe Stars that make up the 12 Conſtellations or Signs.

*Note*, The *inner Edge of the wooden Horizon* is divided into 360 Degrees, or 12 Times 30, allowing 30 Degrees to every Sign or Conſtellation, the Figures of which are uſually drawn there.

The *next Circle* to theſe on the Horizon contains an *Almanack* of the *Old Style* which begins the Year eleven Days later; and the *next Circle* is an Almanack of the *New Style* which begins ſo much ſooner; and theſe ſhew in what Sign the Sun is, and in what

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* This was contrived to be done by Pope *Gregory* in the Year 1582, in this manner. Since three Times 133 Years make near 400 Years, he ordered the additional Day to be omitted at the End of three Centuries ſucceſſively, and to be retained at the 400th Year or 4th Century. But in this Reformation of the Calendar he looked back no farther than the Council of *Nice.* This Order almoſt all Foreign Nations obſerved: *Great Britain* did not obſerve it till the Year 1752, when it was introduced and eſtabliſhed by Act of Parliament.

Degree of that Sign he is every Day in the Year, whether you count by the Old Style or the New.

*Note*, One Side or Edge of the brazen Meridian is alſo divided into 360 Degrees or 4 Times 90; on the upper Semicircle whereof the Numbers uſually begin to be counted from the Equator both ways toward the Poles: On the under Semicircle they begin to be counted from the Poles both ways toward the Equator for ſpecial Uſes, as will afterward appear. And it ſhould be remembered that it is this Edge of the Braſs Circle, which is graduated or divided into Degrees, that is properly the *Meridian Line.*

*Note*, The *Equator* and the *Ecliptick* are called *Unchangeable Circles*, becauſe whereſoever we travel or change our Place on the Earth theſe Circles are ſtill the ſame.

## SECT III.

### *Of the Leſſer Circles.*

THE *Leſſer Circles* divide the Globe into two unequal Parts, and are theſe four, all parallel to the Equator, (*viz.*) the two *Tropics*, and the two *Polar Circles.*

I. The *Tropic of Cancer* juſt touches the *North* Part of the Ecliptick, and deſcribes the Sun's Path for the longeſt Day in *Summer:* It is drawn at 23 ½ Degrees Diſtance from the Equator toward the *North.* And it is it is called the *Tropic of Cancer*, becauſe the Sun enters into that Sign the 21ſt of *June*, the longeſt Day in the Year.

II. The *Tropic of Capricorn* juſt touches the *South* Part of the Ecliptick, and deſcribes the Sun's Path for the ſhorteſt Day in the *Winter:* It is drawn at 23½ Degrees Diſtance from the Equator toward the *South*. And it is called the *Tropic of Capricorn*, becauſe the Sun enters into that Sign the 21ſt of *December*, the ſhorteſt Day in the Year.

*Note*, What I ſpeak of the *ſhorteſt and longeſt Days*, relates only to us who dwell on the *North* Side of the Globe: Thoſe who dwell on the *South* Side have their longeſt Day when the Sun is in *Capricorn*, and their ſhorteſt in *Cancer*.

III. and IV. The North and South *Polar Circles* are drawn at 23½ Degrees of Diſtance from each Pole, or which is all one, at 90 Degrees Diſtance from the contrary Tropic; becauſe the Inhabitants under the *Polar Circles* juſt loſe the Sun under the Horizon one whole Day at their *Midwinter*, or when it is in the utmoſt Part of the contrary Side of the Ecliptick; and they keep it one whole Day or 24 Hours above their Horizon at their *Midſummer*, or when it is in the neareſt Part of their Side of the Ecliptick.

The North Polar Circle is called the *Arctick Circle*, and the South is the *Antarctick*.

Here I might mention the *Five Zones* by which the Ancients divided the Earth, for they are a ſort of broad Circles: But perhaps theſe may be as well referred to the following Part of this Book.

## SECT. IV.

### *Of the Points.*

THE moſt remarkable *Points* in the Heavens are theſe twelve or fourteen.

I, and II, are the two *Poles* of the Earth or Heavens, (*viz.*) the *North* and the *South*, which are ever ſtedfaſt, and round which the Earth or the Heavens are ſuppoſed to turn daily as the Globe does upon theſe Iron Poles. Theſe are alſo the *Poles of the Equator*, for they are at 90 Degrees Diſtance from it.

From one of theſe *Poles* to the other a ſuppoſed Line runs through the Centre of the Globe of Earth and Heavens, and is called the *Axis* or *Axle* of the World.

III, and IV, are the *Zenith*, or Point juſt over our Head; and the *Nadir* or the Point juſt under our Feet, which may be properly called the two *Poles of the Horizon*, for they are 90 Degrees diſtant from it every Way.

V, VI, VII, and VIII, are the four *Cardinal Points* of *Eaſt*, *Weſt*, *North* and *South*: Theſe four Points are in the Horizon which divide it into four equal Parts.

*Note*, For the Uſes of Navigation, or Sailing, each of theſe Quarters of the Heavens, *Eaſt*, *Weſt*, *North* and *South*, are ſubdivided into eight Points, which are called *Rhumbs*; ſo that there are 32 *Rhumbs* or Points in the whole, each containing $11\frac{1}{4}$ Degrees. Theſe are deſcribed on the utmoſt Circle of the Wooden Horizon.

From the NORTH towards the *Eaſt* theſe Points are named *North and by Eaſt*, *North North-Eaſt*, *North-Eaſt and by North*, NORTH-EAST; *North-Eaſt and by Eaſt*, *Eaſt-North-Eaſt*, *Eaſt and by North*, EAST, *&c.* Then from the *Eaſt* toward the *South* it proceeds much in the ſame manner.

The whole Circle of 360 Degrees divided in this Manner is called the *Mariner's Compaſs*, by which they count from what Point of the Heavens the Wind blows, and toward what Point of the Earth they direct their Sailing, which they call *Steering their Courſe.* See Figure 11.

IX, and X, are the *two Solſticial Points:* Theſe are the beginning of the Signs *Cancer* and *Capricorn* in the Ecliptick Line, where the Ecliptick juſt touches thoſe two *Tropics.* Theſe Points ſhew the Sun's Place the longeſt and ſhorteſt Days, (*viz.*) the 21ſt of *June* and the 21ſt of *December.*

*Note*, Theſe two Days are called the *Summer and Winter Solſtices*, becauſe the Sun ſeems to ſtand ſtill, *i. e.* to make the Length of Days neither increaſe nor decreaſe ſenſibly for 20 Days together.

XI, and XII, are *Aries* and *Libra*, or the *two Equinoctial Points*, where the Ecliptick cuts the Equator: When the Sun enters into theſe two Signs, the Days and Nights are equal all over the World. It enters *Aries* in Spring the 21ſt of *March*, which is called the *Vernal Equinox*, and *Libra* in *Autumn* the 23d of *September*, which is called the *Autumnal Equinox*.

Theſe four Points, (*viz.*) two Equinoctial and two Solſticial, divide the *Ecliptick* into the four *Quarters of the Year*.

Here let it be noted, that the twelve *Conſtellations* or *Signs* in the Heavens obtained their Names about two thouſand Years ago or more; and at that Time the Stars that make up *Aries* or the *Ram*, were in the Place where the Ecliptick aſcending cuts the Equator; but now the Conſtellation *Aries* is moved upward toward the Place of *Cancer* near thirty Degrees; and ſo every Conſtellation is moved forward in the Ecliptick from the Weſt toward the Eaſt near thirty Degrees; ſo that the Conſtellation or Stars that make up the Sign *Piſces* are now in the Place where *Aries* was, or where the Ecliptick cuts the Equator in the Spring: And the Conſtellation *Virgo* is now where *Libra* was, or where the Ecliptick cuts the Equator in Autumn. So *Gemini* is in the Summer Solſtice where *Cancer* was;

and *Sagittarius* in the Winter Solſtice where *Capricorn* was: And by this means the Sun is got into the Equinoxes in *Piſces* and *Virgo*, and is arrived at the Solſtices in *Gemini* and *Sagittarius*, *i.e.* when it is among thoſe Stars.

This Alteration is called the *Proceſſion of the Equinox*, *i. e.* of the Equinoctial Signs or Stars, which ſeem to be gone forward, *i. e.* from Weſt to Eaſt; but ſome call it the *Retroceſſion of the Equinox*, *i.e.* of the two Equinoctial Points, which ſeem to be gone backwards, *i.e.* from Eaſt to Weſt. This comes to paſs by ſome ſmall Variation of the Situation of the Axis of the Earth with regard to the Axis of the Ecliptick, round which it moves by a Conical Motion *, and advances 50 Seconds or almoſt a Minute of a Degree every Year, which amounts to one whole Degree in 72 Years, and will fulfil a complete Revolution in 25920 Years. This Period ſome have called the *Platonical Year*, when ſome of the Antients fancied all things ſhould return into the ſame State in which they now are.

Yet we call theſe *Equinoctical* and *Solſticial Points* in the Heaven, and all the *Parts of the Ecliptick* by the ſame antient Names ſtill in Aſtronomy, and mark them ſtill with the ſame Characters (*viz.*) ♈, ♉, ♊, ♋, ♌, *&c.* though the *Conſtellations* themſelves ſeem to be removed ſo much forward.

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* The Axis of the Earth is ſuppoſed to be faſtened at its Middle in the Centre, while both Ends of it, or each of the Poles in this Motion deſcribes a Circle round each Pole of the Ecliptick, which is the Baſe of the Cone. The Vertexes of each of theſe Cones meet in the Centre of the Earth; and by this Motion of the Earth, all the fixt Stars ſeem to be moved from their former Places in Circles parallel to the Ecliptick.

XIII and XIV. Here it may not be improper in the laſt place to mention the *Poles of the Ecliptick* which are two other Points marked generally in the Celeſtial Globe.

If there were an *Axis* thruſt through the Center of the Globe juſt at right Angles with the Plane of the Ecliptick, its Ends or Poles would be found in the two *Polar Circles.* So that a quarter of a Circle or 90 Degrees numbred directly or perpendicularly from the Ecliptick Line ſhew the *Poles of the Ecliptick*, and fix theſe two Points through which the two *Polar Circles* are drawn.

It is uſual alſo in Books of this kind to mention two great Circles called *Colures*, drawn ſometimes on the Celeſtial Globe through the Poles of the World, one of which cutting the Ecliptick in the two Solſticial Points is called the *Solſticial Colure*; the other cutting it in the Equinoctial Points is called the *Equinoctial Colure*, but they are not of much uſe for any common Purpoſes or Practices that relate to the Globe.

I think it may not be amiſs before we proceed farther, to let the Learner ſee a Repreſentation of all the foregoing *Circles and Points* on the Globe, juſt as they ſtand in our *Horizon* at *London*, and ſo far as they can be repreſented on a flat Surface, and in ſtrait Lines.

Let the *North Pole* be raiſed above the North Part of the *Horizon* 51 ½ Degrees which are numbred on the brazen *Meridian*, then let the Globe be placed at ſuch a Diſtance as to make the Convexity inſenſible, and appear as a flat or plain Surface, and let the Eye of the Spectator be juſt level and oppoſite to *c*, which repreſents the *Eaſt* Point of the *Horizon*; then the Globe and the Circles on it will appear nearly as repreſented in Figure III.

The large Circle divided by every 5 Degrees repreſents the *Meridian*, the reſt of the larger and the leſſer Circles are there named, together with the *North* and *South Poles*. Z is the *Zenith* of *London*, N the *Nadir*, H the *South Point* of the Horizon, O the *North Point*, C the *Eaſt* and *Weſt Points*, S the *Summer Solſtice*, W the *Winter Solſtice*, *a the Eclipticks North Pole*, *e* the *Eclipticks South Pole*. The two Epuinoctial Points are repreſented by C, ſuppoſing one to be on this Side, the other on the oppoſite Side of the Globe.

If you would have the two *Colures* repreſented here in this Figure, you muſt ſuppoſe the Meridian to be the *Solſticial Colure*, and the Axis of the World to repreſent the *Equinoctial Colure*. *Note*,

*Note*, This Repreſentation or Projection of the Sphere in ſtrait Lines is uſually called the *Analemma*. See how to project it or to erect this Scheme, *Sect.* XX. *Probl.* XV. *Fig.* XXIII.

## SECT. V.

### *Of Longitude and Latitude on the Earthly Globe, and of different Climates.*

THE various Parts of the *Earth* and Heavens bear various Relations both to one another, and to theſe ſeveral Points and Circles, which have been deſcribed.

*Firſt*, The *Earth* ſhall be conſidered here.

Every Part of the Earth is ſuppoſed to have a *Meridian* Line paſſing over its *Zenith* from North to South through the Poles of the World. It is called the *Meridian Line of that Place*, becauſe the Sun is on it at Noon.

That Meridian Line which paſſes through *Fero*, one of the *Canary-Iſlands*, has been uſually agreed upon by Geographers as a *firſt Meridian*, from which the reſt are counted by the Number of Degrees on the *Equator*. Others have placed their *firſt Meridian* in *Tenariff* another of the *Canary-Iſlands*, which is two Degrees more to the Eaſt, but all this is Matter of Choice and Cuſtom, not of Neceſſity.

The *Longitude of a Place* is its *Diſtance from the firſt Meridian toward the Eaſt meaſured by the Degrees upon the Equator.* So the Longitude of *London* is about 20 Degrees, counting the firſt Meridian at *Fero.*

*Note,* In *Engliſh* Globes or Maps ſometimes the Longitude is computed from the *Meridian of London,* in *French* Maps from *Paris,* &c. for it being purely arbitrary where to fix a *firſt Meridian,* Mariners and Map-Makers determine this according to their Inclination. When only the Word *Longitude* is mentioned in general, it always means the Diſtance eaſtward; but ſometimes we mention the Longitude *weſtward* as well as *eaſtward, i. e.* from *London,* or *Paris,* &c. eſpecially in Maps of particular Countries.

By the Meridian Circles on a Map or Globe the Eye is directed to the true Longitude of any Place according to the Degrees marked on the Equator: And upon this Account the Meridians are ſometimes called *Lines of Longitude.*

The *Latitude of a Place* is its *Diſtance from the Equator toward the North or South Pole meaſured by the Degrees on the Meridian.* So the Latitude of *London* is 51 Degrees 32 Minutes, that is, about 51 ½.

A Place is ſaid to have *North Latitude* or *South Latitude* according as it lies toward the North Pole or South Pole in its Diſtance from the Equator. So *London* has 51 ½ Degrees of North Latitude.

The *Elevation of the Pole* in any particular Place is the *Diſtance of the Pole above the Horizon of that Place meaſured by the Degrees on the Meridian*, and is exactly equal to the *Latitude of that Place:* For the *Pole* of the World or of the Equator is juſt ſo far diſtant from the *Horizon as* the *Zenith* of the Place (which is the Pole of the Horizon) is diſtant from the *Equator.* For which Reaſon the *Latitude of the Place or* the *Elevation of the Pole* are uſed promiſcuouſly for the ſame thing.

The Truth of this Obſervation, (*viz.*) that *the Latitude of the Place and the Poles Elevation are equal,* may be proved ſeveral Ways; I will mention but theſe two. See Figure IV.

Let H C O be the *Horizon*, Z the *Zenith*, or the Point over *London*, E Z the *Latitude* of *London* 51 ½, P O the *Elevation* of the North Pole above the Horizon. Now that E Z is equal to P O is proved thus.

*Demonſtration* I. The Arch Z P added to E Z makes a Quadrant, (for the *Pole* is always at 90 Degrees Diſtance from the *Equator.*) And the Arch Z P added to P O makes a Quadrant, (for the *Zenith* is always at 90 Degrees Diſtance from the *Horizon.*) Now if the Arch Z P added either to E Z or to PO completes a Quadrant, then EZ muſt be equal to PO.

*Demonſtration* II. The *Latitude* EZ muſt be the ſame with the *Poles Elevation* PO: For * the Complement of the Latitude, or the Heighth of the Equator above the Horizon EH is equal to the Complement of the Poles Elevation PZ. I prove it thus. The Equator and the Pole ſtanding at right Angles as ECP, they complete a Quadrant, or include 90 Degrees: Then if you take the Quadrant ECP out of the Semicircle, there remains PO the elevated Pole, and EH the Complement of the Latitude, which complete another Quadrant. Now if the Complement of the Latitude added to the Elevation of the Pole, will make a Quadrant, then the Complement of the Latitude is equal to the Complement of the Poles Elevation, and therefore the Latitude is equal to the Poles Elevation; for where the Complements of any two Arches are equal, the Arches themſelves muſt alſo be equal.

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* *Note*, The *Complement* of any Arch or Angle under 90 Degrees denotes ſuch a Number of Degrees as is ſufficient to make up 90; as the *Complement* of 50 Degrees is 40 Degrees, and the *Complement* of $51\frac{1}{2}$ is $38\frac{1}{2}$ Degrees. And ſo the Complement of the Sine or Tangent of any Arch is called the *Co-ſine* or *Co-tangent*: So alſo in Aſtromony and Geography we uſe the Words *Co-latitude*, *Co-altitude*, *Co-declination*, &c. for the Complement of the Latitude, Altitude, or Declination, of which Words there will be more frequent Uſe among the *Problems*.

As every Place is ſuppoſed to have its proper *Meridian* or *Line of Longitude*, ſo every Place has its proper *Line of Latitude* which is a Parallel to the Equator. By theſe Parallels the Eye is directed to the Degree of the *Latitude of the Place* marked on the Meridian, either on Globes or Maps.

By the *Longitude* and *Latitude* being given you may find where to fix any Place, or where to find it in any Globe or Map: For where thoſe two ſuppoſed Lines (*viz.*) the *Line of Longitude* and *Parallel of Latitude* croſs each other, is the Place enquired. So if you ſeek the Longitude from *Fero*, 20 Degrees, and the Latitude 51 ½ Degrees, they will ſhew the Point where *London* ſtands.

Thoſe *Parallels of Latitude* which are drawn at ſuch Diſtances from each other near and nearer to the Poles, as determine the longeſt Days and longeſt Nights of the Inhabitants to be half an Hour longer or ſhorter, include ſo many diſtinct *Climates*, which are proportionally hotter or colder according to their Diſtance from the Equator. Though it muſt be owned that we generally uſe the Word *Climate* in a more indeterminate Senſe, to ſignify a *Country lying nearer or farther from the Equator*, and conſequently *hotter or colder*, without the preciſe Idea of its longeſt Day being juſt half an Hour ſhorter or longer than in the next Country to it.

The

The *Latitude* is never counted beyond 90 Degrees, becauſe that is the Diſtance from the *Equator* to the *Pole:* The *Longitude* ariſes to any Number of Degrees under 360, becauſe it is counted all round the Globe.

If you travel never ſo far directly towards *Eaſt* or *Weſt* your *Latitude* is ſtill the ſame, but *Longitude* alters. If directly toward *North* or *South*, your *Longitude* is the ſame, but *Latitude* alters. If you go obliquely, then you change both your *Longitude and Latitude.*

The *Latitude of a Place*, or the *Elevation of the Pole* above the Horizon of that Place, regards only the *Diſtance Northward or Southward*, and is very eaſy to be determined by the Sun or Stars with certainty, as Sect. XX. Prob. VII, and IX. becauſe, when they are upon the *Meridian* they keep a regular and known Diſtance from the *Horizon*, as well as obſerve their certain and regular Diſtances from the *Equator*, and from the two *Poles*, as ſhall be ſhewn hereafter: So that either by the Sun or Stars (when you travel Northward or Southward) it may be found preciſely how much your *Latitude* alters.

But it is exceeding difficult to determine what is the *Longitude of a Place*, or the Diſtance of any two Places from each other *Eaſtward* or *Weſtward* by the Sun or Stars, becauſe they are always moving round from *Eaſt* to *Weſt.*

*The Longitude of a Place* has been therefore uſually found out and determined by meaſuring the Diſtance travelled on the Earth or Sea, from the *Weſt* toward the *Eaſt*, ſuppoſing you know the Longitude of the Place whence you ſet out.

## SECT. VI.

## *Of Right Aſcenſion, Declination, and Hour Circles.*

HAVING conſidered what reſpect the *Parts of the Earth* bear to theſe artificial Lines on the Globe, we come, *ſecondly*, to ſurvey the ſeveral Relations that the *Parts of the Heavens*, the Sun or the Stars, bear to theſe ſeveral imaginary Points and artificial Lines or Circles.

The *Right Aſcenſion* of the Sun or any Star is its *Diſtance from that Meridian which paſſes through the Point* Aries, *counted toward the Eaſt, and meaſured on the Equator*; it is the ſame Thing with *Longitude on the Earthly Globe.*

The *Hour* of the Sun or any Star is reckoned alſo by the Diviſions of the Equator; but the *Hour* differs from the *Right Aſcenſion* chiefly in this, (*viz.*) The *Right Aſcenſion* is reckoned from that Meridian which paſſes through *Aries*; the *Hour* is reckoned on the Earthly Globe, from that Meridian which paſſes through the *Town or City required*; or it is reckoned on the heavenly Globe from that Meridian which paſſes through the *Sun's Place* in the Eclip-tick, and which, when it is brought to the Brazen Meridian, repreſents *Noon* that Day.

There is alſo this Difference. The *Right Aſcenſion* is often computed by ſingle Degrees all round the Equator, and proceeds to 360: The *Hour* is counted by every 15 Degrees from the Meridian of Noon, or of Midnight, and proceeds in Number to 12, and then begins again: Though ſometimes the *Right Aſcenſion* is computed by *Hours* alſo inſtead of Degrees, but proceeds to 24. So the Sun's *Right Aſcenſion* the 10th of *May* is 59 Degrees, or as ſometimes it is called 3 Hours and 56 Minutes.

The ſame Lines which are called *Lines of Longitude* or Meridians on the Earth are called *Hour Circles* on the heavenly Globe, if they be drawn through the Poles of the World at every 15 Degrees on the Equator, for then they will divide the 360 Parts or Degrees into 24 Hours.

*Note*, As 15 Degrees make *one Hour*, ſo 15 Minutes of a Degree make *one Minute in Time*, and one whole Degree makes four *Minutes in Time*.

Note, *Degrees* are marked ſometimes with ($^d$) or with a ſmall Circle (°), *Minutes of Degrees* with a Daſh ('), *Seconds of Minutes* with a double Daſh (''), *Hours* with ($^h$), *Minutes of Hours* ſometimes with ($^m$) and ſometimes a Daſh: *Seconds* with a double Daſh.

By theſe *Meridians* or *Hour-Lines* croſſing the Equator on the heavenly Globe, the Eye is directed to the true *Hour*, or the Degree of *Right Aſcenſion* on the Equator, though the Sun or Star may be far from the Equator.

By theſe you may alſo compute on the Earthly Globe what Hour it is at any Place in the World, by having the true Hour given at any other Place, and by changing the Degrees of their *Difference of Longitude* into Hours.

But ſince ſeveral *Queſtions* or *Problems* that relate to the Hour, cannot be ſo commodiouſly reſolved by theſe few *Meridians* or *Hour-Lines*, becauſe every Place on the Earth hath its proper Meridian where the Sun is at 12 a Clock, therefore there is a Braſs *Dial-plate* fixed at the North-pole in the Globe, whoſe 24 Hours do exactly anſwer the 24 Hour Circles which might be drawn on the Globe: Now the *Dial* being fixed, and the *Pointer* being moveable, this anſwers all the Purpoſes of having an infinite Number of Hour Circles drawn on the Globe, and fitted to every Spot on the Heavens,

vens or the Earth. For the *Pointer* or *Index* may be ſet to 12 a Clock, when the Sun's true Place in the Heavens, or when any Place on the Earth is brought to the Braſs-Meridian, and thus the Globe moving round with the *Index* naturally repreſents, and ſhews by the Dial-Plate the 24 Hours of any Day in the Year, or in any particular Town or City.

*Note*, The upper 12 a Clock is the Hour of *Noon*, the lower 12 is the *Midnight* Hour, when the Globe is fixed for any particular Latitude where there are Days and Nights.

The *Declination* of the Sun or Stars is their *Diſtance from the Equator toward the North or South Pole, meaſured on the Meridian*; and it is the ſame Thing with *Latitude on the Earthly Globe.*

*Note*, The Sun in the vernal or autumnal Equinoxes, and the Stars that are juſt on the Equator have no Declination.

*Parallels of Declination* are Lines parallel to the Equator, the ſame as the *Parallels of Latitude* on the Earthly Globe. In the Heavens they may be ſuppoſed to be drawn through each Degree of the Meridian, and thus ſhew the Declination of all the Stars; or they may be drawn through every Degree of the *Ecliptick*, and thus repreſent the *Sun's Path*, every Day in the Year. Theſe parallel Lines alſo would lead the Eye to the Degree of the Sun's or any particular Stars *Declination* marked on the Meridian.

The Declination is called *North* or *South Declination* according as the Sun or Star lies Northward or Southward from the Equator.

Obſerve here, that as any *Place*, *Town*, or *City* on Earth is found determined by the *Parallel of its Latitude* croſſing its *Line of Longitude*; ſo the proper Place of the *Sun* or *Star* in the Heavens is found and determined by the Point where its *Parallel of Declination* croſſes its *Meridian* or *Line of Right Aſcenſion*; which indeed are but the ſelf ſame things on both the Globes, though Aſtronomers have happened to give them different Names.

*Note*, The Sun's *utmoſt Declination Northward* in our Summer is but 23 ½ Degrees; and it is juſt ſo much *Southward* in our Winter; for then he returns again: There the *Tropics* are placed which deſcribe the *Path of the Sun* when fartheſt from the Equator, at Midſummer, or Midwinter: Theſe two Tropics are his *Parallels of Declination* on the longeſt and ſhorteſt Day.

While the Sun gains 90 Degrees on the *Ecliptick*, (which is an oblique Circle) in a Quarter of a Year, it gains but 23 ½ Degrees of direct Diſtance from the *Equator* meaſured on the *Meridian*; this appears evident on the Globe, and may be repreſented thus in Figure v.

Let the Semicircle ♈ P ♎ be the Meridian of the Northern Hemiſphere, the Line ♈ C ♎ be the Equator or the Sun's Path at *Aries* and *Libra*, the Arch ♈ ♋ ♎ the Ecliptick, the Line T ♋ O the Summer Tropic, the Line *a e* the Sun's Path when it enters *Gemini* and *Leo*, the Line *n s* the Sun's Path when it enters *Taurus* and *Virgo*: Then it will appear that in moving from ♈ to ♉ the Sun gains 30 Degrees in the *Ecliptick*, in about a Month, and at the ſame Time 12 Degrees of *Declination*, *viz.* from ♈ to *n*. Then moving from ♉ to ♊ in a Month more it gains 30 Degrees on the *Ecliptick*, and 8 ¼ Degrees of *Declination*, *viz.* from *n* to *a*. Then again from ♊ to ♋ in a Month more it gains 30 Degrees on the *Ecliptick*, and but 3 ¼ Degrees of *Declination*, *viz.* from *a* to T. I might alſo ſhew the ſame Difference between its *Declination* and its Motion on the *Ecliptick* in its Deſcent from ♋ to ♌, ♍, and ♎.

By drawing another Scheme of the ſame Kind below the Line ♈ C ♎, we might repreſent the Sun's Deſcent towards the Winter Solſtice, and its Return again to the Spring; and thereby ſhew the ſame Differences between the *Sun's Declination* and its *Motion on the Ecliptick* in the Winter Half-Year as the preſent Scheme ſhews in the Summer Half-Year.

Hereby it is evident how it comes to paſs, that the *Sun's Declination* alters near half a

Degree every Day juſt about the *Equinoxes*; but it ſcarce alters ſo much in 10 or 12 Days on each Side of the *Solſtices*: And this ſhews the Reaſon why the Length of Days and Nights changes ſo faſt in *March* and *September*, and ſo exceeding ſlowly in *June* and *December*: For according to the Increaſe of the Sun's Declination in Summer, its Semidiurnal Arc * will be larger, and conſequently it muſt be ſo much longer before it comes to its full *Height* at Noon, and it ſtays ſo *much longer* above the *Horizon* before it ſets.

Thus while the *Sun's Declination* increaſes or decreaſes by ſlow Degrees, the *Length of the Days* muſt increaſe and decreaſe but very ſlowly; and when the *Sun's Declination* increaſes and decreaſes ſwiftly, ſo alſo muſt the *Length of the Days*: All which are very naturally and eaſily repreſented by the Globe.

## SECT. VII.

## *Of Longitude and Latitude on the Heavenly Globe, and of the Nodes and Eclipſes of the Planets.*

THE *Longitude* and *Latitude* in Aſtronomy are quite different Things from

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* The *Diurnal Arc* is that Part of the Circle or Parallel of Declination which is above the *Horizon*; and the Half of that Part is called the *Semidiurnal Arc*.

*Longitude* and *Latitude* in Geography, which is ready to create ſome Confuſion to Learners.

The *Longitude* of the Sun or any Star is its *Diſtance from the Point* Aries *eaſtward, meaſured in the Ecliptick.* This is a ſhort Way of deſcribing it, and agrees perfectly to the Sun: But in Truth a Star's *Longitude is its Diſtance eaſtward from a great Arch drawn perpendicular to the Ecliptick through the Point* Aries, *and meaſured on the Ecliptick.*

We do not ſo uſually talk of the *Sun's Longitude*, becauſe we call it *his Place in the Ecliptick*, reckoning it no farther backward than from the Beginning of the Sign in which he is. So the 25th Day of *June*, we ſay the Sun is in the 14th Degree of *Cancer*, and not in the 104th Degree of *Longitude.*

The *Latitude* of a Star or Planet is its *Diſtance from the Ecliptick, meaſured by an Arch, drawn through that Star perpendicular to the Ecliptick.*

*Longitude* and *Latitude* on the Heavenly Globe bear exactly the ſame Relation to the *Ecliptick* as they do on the Earthly Globe to the *Equator.* As the *Equator* is the Line *from* which the *Latitude* is counted, and *on* which the *Longitude* is counted on the Earthly Globe, ſo the *Ecliptick* is the Line *from* which the *Latitude*, and *on* which the *Longitude* are counted on the Heavenly Globe.

And thus the *Lines of Latitude* in the Heavenly Globe are all ſuppoſed Parallels to the *Ecliptick*, and the *Lines of Longitude* cut the Ecliptick at right Angles, and all meet in the *Poles* of the *Ecliptick*, bearing the ſame Relation to it as on the Earthly Globe they do to the Equator.

The *Latitude* of a Star or Planet is called *Northern* or *Southern* as it lies on the *North* or *South* Side of the Ecliptick.

The Sun has no *Latitude*, becauſe it is always in the *Ecliptick*. This Relation of *Latitude* therefore chiefly concerns the Planets and Stars.

The *Fixed Stars* as well as the *Planets* have their various *Longitudes* and *Latitudes*; and their particular *Place* in the Heavens may be aſſigned and determined thereby, as well as by their *Right Aſcenſion and Declination* which I mentioned before; and *Aſtronomers* uſe this Method to fix exactly the *Place* of a *Star* *. But I think it is eaſier for a Learner to find a *Star's Place* by its Declination, and *Right Aſcenſion*; and the common Aſtronomical Problems ſeem to be ſolved more naturally and eaſily by this Method.

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* Aſtronomers know that not only the 12 Conſtellations of the *Zodiac*, but alſo all the *Fixed Stars* ſeem to move from the Weſt toward the Eaſt about 50″ in a Year, or one Degree in 72 Years, in Circles parallel to the *Ecliptick*. Therefore their *Declination* is a little altered in 72 Years Time, that being meaſured from the *Equator*: But their *Latitude* never alters, that beng meaſured from the *Ecliptick*: And upon this Account Aſtronomers uſe the *Latitude* rather than the *Declination* in their Meaſures, beoauſe it abides the ſame for ever.

It may be here mentioned, though it is before its proper Place, that the ſeveral Planets, *viz. Saturn*, *Jupiter*, *Mars*, *Venus*, *Mercury*, and the *Moon*, make their Revolutions at very different Diſtances from the Earth, from the Sun, and from one another; each having its diſtinct *Orbit* or Path nearer or farther from us. And as each of their *Orbits* is at vaſtly different Diſtances, ſo neither are they perfectly parallel to one another, nor to the *Ecliptick* or yearly Path of the Sun.

Thence it follows that theſe Planets have ſome more, ſome leſs *Latitude*, becauſe their Orbits or Paths differ ſome few Degrees from the Sun's Path, and interſect or croſs the *Ecliptick*, at two oppoſite Points in certain ſmall Angles of two, three, four or five Degrees, which Points are called the *Nodes*.

The *Node* where any Planet croſſes the Ecliptick aſcending to the Northward is called the *Dragon's Head*, and marked thus ☊. Where the Planet croſſes the Ecliptick deſcending to the Southward, it is called the *Dragon's Tail*, and marked thus ☋.

It is very difficult to repreſent the *Latitude of the Planets* in their different Orbits either upon a Globe, or upon a flat or plain Surface; the beſt Way that I know is, to take two ſmall Hoops of different Sizes, as in Figure XI. and thruſt a ſtrait Wire *c o* through them both in the two oppoſite Parts of their Circumference: Then turn the innermoſt Hoop (which may repreſent the *Path* of the *Moon*) ſo far aſide or obliquely as to make an Angle of $5\frac{1}{4}$ Degrees with the outermoſt Hoop, (which repreſents the *Sun's Path.*) Thus the two Points *c* and *o* or ☊ and ☋ where the Wire joins the Hoops, are the two *Nodes* or the Points of Interſection.

This Difference of *Orbits* of the Planets and their *Interſections* or *Nodes*, may be repreſented alſo by two circular Pieces of Paſtboard as in Figure XII. When the leſs (whoſe Edge repreſents the Moon's Orbit,) is put half Way through a Slit A B, that is made in the Diameter of the larger (or the Sun's Orbit,) and then brought up near to a Parallel or level with the Larger within $5\frac{1}{4}$ Degrees. Thus the two *Nodes* will be repreſented by A and B.

If the *Moon*'s Path and the *Sun*'s were preciſely the ſame, or parallel Circles in the ſame Plane, then at every *New Moon* the *Sun* would be eclipſed by the Moon's coming between the Earth and the Sun: And at every *Full Moon* the *Moon* would be eclipſed by the Earth's coming between the Sun and the Moon. But ſince the Planes of their Orbits or Paths are different, and make Angles with each other, there cannot be *Eclipſes* but in or near the Place where the

Planes of their Orbits or Paths interſect or croſs each other.

In or very near theſe *Nodes*, therefore, is the only Place where the Earth or Moon can hide the Sun or any Part of it from each other, and cauſe an *Eclipſe* either *total* or *partial:* And for theſe Reaſons the Orbit or Path of the Sun is called the *Ecliptick.*

The Eclipſes of other Planets, or of any part of the Sun by their Interpoſition, are ſo very inconſiderable as deſerve not our preſent Notice.

## SECT. VIII.

### *Of Altitude, Azimuth, Amplitude, and various Riſings and Settings of the Sun and Stars.*

THE *Altitude* of the Sun or Star is its *Heighth above the Horizon, meaſured by the Degrees on the Quadrant of Altitudes.*

As the Height of the Sun at Noon is called its *Meridian Altitude*, or its *Culminating*, ſo the Height of the Sun in the Eaſt or Weſt is ſometimes called its *Vertical Altitude.*

The *Quadrant of Altitudes* is a thin Label of Braſs, with a Nut and Skrew at the End of it, whereby it is faſtened to the *Meridian* at the *Zenith* of any Place; now by bending this down to the *Horizon*, you find the Altitude of any Star or Point in the Heavens, becauſe the Label is divided into 90 Degrees counting from the Horizon upward.

*Circles parallel to the Horizon*, ſuppoſed to be drawn round the Globe, through every Degree of the *Quadrant of Altitudes* leſs and leſs till they come to a Point in the Zenith, are called *Parallels of Altitude*, or ſometimes in the old *Arabick* Name *Almicantars*. But theſe can never be actually drawn on the Globe, becauſe the *Horizon* and *Zenith* are infinitely variable, according to the different Latitudes of Places. In the VIth Figure, ſuppoſe Z to be the Zenith, N the Nadir, H R the Horizon, and the ſtrait Lines *a b*, *f g*, *k m*, will repreſent the Parallels of Altitude.

*Note*, The Sun being always higheſt on the *Meridian*, or at *Noon*, it deſcends in an Arch towards the Horizon in order to *ſet*, by the ſame Degrees by which it aſcended from the Horizon after its *riſing*. Stars and Planets *riſe* and *ſet*, and come to the *Meridian* at *all different Hours* of the Day or Night according to the various Seaſons of the Year, or according to the Signs in which the Planets are.

As the Word *Altitude* is uſed to ſignify the Height of the Sun or Star above the Horizon, ſo the *Depreſſion* of the Sun or Star is its Diſtance from or below the Horizon.

The

The *Azimuth* of the Sun or Star is its *Diſtance from any of the four Cardinal Points*, Eaſt, Weſt, North and South, *meaſured by the Degrees of the Horizon.*

*Note*, When we ſpeak of the *Sun's Azimuth* in general, we uſually mean his *Diſtance from the South*: But when his Diſtance from the North, Eaſt, or Weſt, is intended, we ſay, his *Azimuth from the North*, the *Eaſt*, or the *Weſt*.

*Great Circles* cutting every Degree of the *Horizon* at Right Angles, and meeting in the *Zenith* and *Nadir* are called *Azimuthal* or *Vertical Circles*. They direct the Eye to the Point of the Sun or Star's *Azimuth on the Horizon*, though the Sun or Star may be far above, or below the Horizon.

Note, *Vertical Circles* are the ſame with Regard to the Zenith, Nadir, and the Horizon, as *Meridians* or *Hour Circles* are with Regard to the two Poles of the World and the Equator. But theſe *Vertical Circles* can never be actually drawn on a Globe, becauſe the *Zenith*, *Nadir*, and *Horizon* are ever variable. See them repreſented Figure VI. by the Lines Z H N, Z *a* N, *e* N, Z *&c.* ſuppoſing H R to be the Horizon.

*Note*, The *Quadrant of Altitudes* being moveable when one End of it is faſtened at the Zenith, the graduated Edge of it may be laid over the Place of the Sun or Star, and brought down to the Horizon; then it repreſents any *Azimuth* or *Vertical Circle*, in which the Sun or Star is; and thus it ſhews the Degree of its Azimuth on the Horizon.

*Note*, The Azimuth of the Sun or Star from the *Eaſt* or *Weſt* Points of the Horizon at its riſing or ſetting, is called its *Amplitude*.

*Note*, The Sun is always in the South at Noon, or 12 a-Clock, and in the North at *Midnight*, viz. in *Europe* and all Places on this Side on the Equator. But it is not at the Eaſt or Weſt at *ſix* a-Clock any other Day in the Year beſides the two Equinoctial Days, as will eaſily appear in an *oblique Poſition of the Sphere*, (of which ſee the next Section) and eſpecially in the laſt Section where the *Analemma* ſhall be more fully deſcribed.

Yet the Relation which the *Parallels of Altitude* bear to the *Vertical Circles*, and which theſe *Vertical* or *Azimuthal* Circles bear to the *Meridians* or *Hour Circles*, may be repreſented to the Eye in Figure VI. and VII.

In Figure VI. Suppoſe the outermoſt Circle be the Meridian, H R the Horizon, Z the Zenith, N the Nadir; then *d b*, *f g*, *k m*, will be *Parallels of Altitude*: And Z *a* N, Z *e* N, Z *o* N, Z C N, &c. will be *Vertical Circles*, or Circles of *Azimuth* croſſing the others at Right Angles.

Thus Z C N is the vertical Circle of Eaſt or Weſt. And in this Scheme *s a* or *f* H will be the Arch of the Altitude of the Star *s*, and H *a* will be its *Azimuth* from the Meridian; and C *a* will be its Azimuth from the Eaſt to Weſt.

But if the Line H R be ſuppoſed to repreſent the Equator, then Z and N will be the two Poles of the World, and then *d b*, *f g*, &c. will be *Parallels of Latitude* on Earth, or *Parallels of Declination* in the Heavens. Then alſo the Arches Z H N, Z *a* N, Z *e* N, Z *o* N, Z C N, will be *Meridians*, or *Lines of Longitude* on Earth, and *Hour Circles* in the Heavens.

In Figure VII. Let the utmoſt Circle be the Meridian, H R the Horizon, Z the Zenith, N the Nadir, E Q the Equator, P L the Axis of the World, or rather the two Poles, North and South; then Z H N, Z *a* N, Z *e* N, Z C N will be Circles *of Azimuth*: P E L, P *o* L, P *u* L, P C L, *&c.* will be *Hour Circles*.

And in this Poſition the Star *s* will have T *s*, *i. e.* equal to *E o* for its *Hour* from Noon or the Meridian; but its Azimuth from Noon or the South or Meridian will be H *e*. Or if you reckon its Azimuth from the Eaſt or Weſt Vertical (which is Z C N) it will be found to be C *e*, while its Hour reckoned from P 6 C L (which is the Six a-Clock Hour-Line) will be found to be 6 *s* or C *o*.

Thus it will appear how the *Hour* of the Sun differs from its *Azimuth*, and that both of them are numbered, or counted from the Meridian P Z E H L N; yet they do not by any Means keep equal Pace with one another, one being numbered along the *Equator* E Q, the other numbered along the *Horizon* H R.

Thus you ſee moſt evidently that if you ſuppoſe the Sun *s* * to be in the *Tropic of Cancer* repreſented by the Line T ♋, the Difference between the *Hour* and *Azimuth* will appear to be very great; and that the Sun's *Azimuth* from Noon H *e* increaſes a great deal faſter than his *Hour* T *s* doth in the Middle of Summer. And if another Line K ♑ were drawn to repreſent the *Tropic of Capricorn*, the Sun's *Azimuth* from Noon will appear to increaſe a great Deal ſlower than his Hours do in the Middle of Winter.

I think it ſhould not utterly be omitted here what is mentioned in almoſt all Writings of this Kind, (*viz.*) that a Star is ſaid to *riſe* or *ſet Coſmically* when it riſes or ſets at *Sun-riſing*.

It is ſaid to *riſe* or *ſet Achronically* if it riſe or ſet at *Sun-ſetting*.

A Star is ſaid to *riſe Heliacally* when it is juſt come to ſuch a Diſtance from the Sun as that it is no longer hid by the Sun-Beams. And it is ſaid to *ſet Heliacally* when the Sun approaches ſo near to it as that it begins to diſappear from our Sight being hid by the Beams of the Sun.

The Fixed Stars and the three Superior Planets, *Mars*, *Jupiter*, and *Saturn*, riſe *Heliacally* in the Morning, but the *Moon* in the Evening; for it is in the Evening the *New Moon* firſt appears, coming from her Conjunction with the Sun.

*Note*, This Sort of Riſing and Setting of the Stars is alſo called *Poetical*; becauſe the ancient *Poets* frequently mention it.

## SECT. IX.

### *Of the Inhabitants of the Earth according to the Poſitions of the Sphere, the Zones, &c.*

IN order to make the *Doctrine of the Sphere* or Globe yet more plain and intelligible, let us conſider the *Inhabitants* of the ſeveral Parts of the World, who may be diſtinguiſhed three Ways, (1.) According to the various *Poſitions of the Globe.* (2.) According to the *five Zones.* (3.) In *Relation to one another.*

*Firſt*, Let us conſider them according to the *various Poſitions of the Globe* or *Sphere*, which are either *Direct*, *Parallel*, or *Oblique*.

Theſe three Poſitions of the Sphere are repreſented in Figure VIII, IX, X, in each of which the utmoſt Circle is the *Meridian*

H R is the *Horizon*, E Q the *Equator*, ♋ ♑ the *Ecliptick*, S N the *Axis* of the World, N the *North Pole*, S the *South*, Z D the *Vertical Circle* of *Eaſt* and *Weſt*, Z the *Zenith*, D the *Nadir*, ♋ A the *Tropic of Cancer*, C ♑ the *Tropic of Capricorn*. The various Poſition of theſe Lines or Circles will appear by the following Deſcriptions.

I. A *Direct* or *Right Sphere* Figure VIII. is when the *Poles* of the World are in the *Horizon*, and the *Equator* paſſes through the *Zenith*: This is the Caſe of thoſe who live directly under the *Line* or *Equator*.

Here the Inhabitants have no *Latitude*, no *Elevation* of the Pole: The *North* or *South Poles* being in the *Horizon* they may very nearly ſee them both.

All the Stars do once in twenty four Hours riſe and ſet with them, and all at right Angles with the *Horizon*.

The Sun alſo, in whatſoever Parallel of *Declination* he is, riſes and ſets at right Angles with the *Horizon*; their Days and Nights therefore are always equal, becauſe the *Horizon* exactly cuts the Sun's Diurnal Circles in Halves.

They have two Summers every Year, (*viz.*) when the Sun is in or near the two *Equinoctial Points*, for then he is juſt over their Heads at Noon, and darts his ſtrongeſt Beams. And they have two Winters. (*viz.*) when the Sun is in or near the *Tropics of Cancer* and *Capricorn*; for then the Sun is fartheſt diſtant from them, though even then it is nearer than it is to us in *England* at Midſummer.

II. A *Parallel Sphere*, Figure IX. is where the *Poles* of the World are in the *Zenith* and *Nadir*: And the *Equator* is in the *Horizon*.

Now if there were any Inhabitants thus directly under the *North* and *South* Poles, they would have only one Day of ſix Months long, and one Night of ſix Months, in a whole Year, according as the Sun is on this or the other Side of the *Equator*; for the Sun moving ſlowly in the *Ecliptick* on the *North* Side of the *Equator* half a Year, would be all that Time above the *Horizon* to the Inhabitants at the *North Pole*, though it went round them daily: And the Sun moving in the *Ecliptick* on the *South* Side of the *Equator* half a Year, would be below their *Horizon* all that Time. The ſame might be ſaid concerning the Inhabitants of the *South Pole*.

The two Equinoctial Days, or when the Sun is in the Points *Aries*, or *Libra*, the Day and Night are equal all the World over; and this is true in a Senſe to thoſe who live under the *Poles*; for the Centre of the Sun is in their *Horizon*. Thus half the Sun is above their *Horizon*, and half below it for 24 Hours together.

Thus, though the Polar Inhabitants begin to loſe the Sun at the *Autumnal Equinox*, they are not in utter Darkneſs all the Time of the Sun's Abſence: For the *Twilight* laſts till the Sun is 18 Degrees below their *Horizon*, and that is till he has 18 Degrees of *Declination.* The Inhabitants of the North Pole are therefore without the Twilight only from the 2d of *November* till the 18th of *January*.

Let it be noted alſo that the *Refraction* of the Rays through the thick Air or *Atmoſphere* makes the *Sun* appear above their *Horizon* ſeveral Days ſooner, and diſappear ſeveral Days later, than otherwiſe it would do. It may be added in Favour of their Habitations too, that the Moon when ſhe is brighteſt, (*viz.*) from the firſt Quarter to the laſt, does not ſet during their Middle of Winter: For in that Part of her Month ſhe is moſt oppoſite to the Sun, and is therefore in that Part of the Heavens which is moſt diſtant from the Sun while he never riſes.

The Parallels of the Sun's *Declination* in this Poſition of the Sphere are all parallel to the *Horizon*; and are the ſame with the Parallels of his *Altitude*, and therefore his *higheſt Altitude* with them can never exceed 23 ½ Degrees.

The Stars that they could ſee would be always the ſame, making perpetual Revolutions round them, and never ſet nor riſe, nor be higher or lower. And the Planets during half their Periods will be above their *Horizon*, as *Saturn* 15 Years, *Jupiter* 6, *Mars* 1, *&c.*

III. An *Oblique Sphere*, Figure x. is where the *Latitude* or *Elevation* of the Pole is at any Number of Degrees leſs than 90. Therefore all the Inhabitants of the Earth (except under the *Equator* and the *Poles*) have an *Oblique Sphere.*

Here the *Equator* and all the Parallels of *Declination* cut the *Horizon* obliquely, therefore the Sun and Stars always riſe and ſet at oblique Angles with the *Horizon.*

As one Pole of the World is always in their View, and the other is never ſeen, ſo there are ſome Stars which never ſet, and others which never riſe in their *Horizon.*

Their Days and Nights are of very different Lengths according to the different *Declination* of the Sun in the ſeveral Seaſons of the Year.

In this *Oblique Poſition* of the Sphere, Aſtronomers ſometimes talk of the *Oblique Aſcenſion* of the Sun or Stars; and in order to obtain a clearer Idea of it, let us again conſider the *Right Aſcenſion*, which is the Sun or Star's *Diſtance from that Meridian, which paſſes through the Point* Aries, *meaſured on the Equator.*

Or it may be expreſſed thus: The *Right Aſcenſion* is that Degree of the *Equator* which comes to the *Meridian* together with the Sun or Star, conſidered in its Diſtance from the Point *Aries.*

But the *Oblique Aſcenſion* is that Degree of the *Equator* which in an oblique Sphere *riſes* together with the Sun or Star conſidered in its Diſtance from the Point *Aries.*

*Note*, That in a *Right* or *Direct Sphere* all the heavenly Bodies can only have *Right Aſcenſion*, and no *Oblique Aſcenſion*; becauſe the ſame Point or Degree of the *Equator* that *riſes* with them comes alſo to the *Meridian* with them: But in an *Oblique Sphere* there is ſometimes a great deal of Difference between the Point that riſes with them and the Point that comes with them to the Meridian.

Now the Difference between the *Right Aſcenſion* of the Sun or Star, and its *Oblique Aſcenſion* is called the *Aſcenſional Difference.*

*Note*, Concerning the Stars in the *Equator*, that their Right and Oblique Aſcenſion are equal: Therefore the Sun in the Equinoxes riſing at Six and ſetting at Six has no *Aſcenſional Difference:* But as he goes onward from the Equator toward the Winter Solſtice, he riſes after Six; and as he goes toward the Summer he riſes before Six; and the *Diſtance of his riſing or ſetting from Six a-Clock* is called the *Aſcenſional Difference.*

And perhaps it is ſufficient as well as much eaſier for a Learner to remember that the Time of the Sun or Star's riſing or ſetting before or after Six a-Clock is called by Aſtronomers the *Aſcenſional Difference* without taking any Notice at all of the *Oblique Aſcenſion*, which is neither ſo eaſy to be apprehended or remembered.

The *Second* Diſtinction of the Inhabitants of the Earth may be made according to the *five Zones*, which they inhabit; this was an ancient Diviſion of the Globe.

The *Zones* are broad Circles, five of which cover or fill up the Globe. There are two *Temperate*, two *Frigid* or cold, and one *Torrid* or hot.

The *Torrid* or *burning Zone* is all the Space that lies between the two *Tropics*; it was once counted uninhabitable, becauſe of exceſſive Heat, being ſo near the Sun; but later Diſcoveries have found many and great Nations inhabiting thoſe Parts which contain the greateſt Part of *Africa* and of South *America.*

The two *Frigid* or cold *Zones* are thoſe Spaces which are included within the two *Polar Circles*, with the Pole in the Centre, at great Diſtance from the Sun, ſcarcely habitable by Reaſon of the Cold. There lies *Greenland*

*Greenland* and *Lapland* toward the *North* Pole. The *South* Pole and Polar Regions are undiſcovered.

The two *temperate Zones* are thoſe Spaces that lie on either Side of the Globe between the *Tropics* and the *Polar Circles*, where the Sun gives a moderate Heat, and makes thoſe Parts moſt convenient for the Habitation of Men. All *Europe*, and the greateſt Part of *Aſia*, and *North America*, lie in the North temperate Zone.

*Note*, That the *Torrid Zone* lying between the *two Tropics*, every Place in it has the Sun in the *Zenith*, or exactly over their Heads once or twice in every Year.

Thoſe who live under the *Tropic of Cancer* have their Winter when the Sun is in *Capricorn*. Thoſe who live under the *Tropic of Capricorn* have their Winter when the Sun is in *Cancer*. Thoſe who live under the Equator have (as I ſaid before) two Winters in the Year; though indeed there is ſcarce any Seaſon can be called *Winter* within the Limits of the *Torrid Zone*.

Thoſe who live juſt within the Borders of the two *Frigid Zones*, loſe the Sun for twenty four Hours together at Midwinter when the Sun is in the *contrary Tropic*: And thoſe Places that are nearer and nearer to the Poles loſe the Sun for two, three, four, five, ſix Days, for whole Weeks or Months together at their Winter, or when the Sun is near the *contrary Tropic.*

What is ſaid concerning the Loſs of Light a whole Day or Week or Month at *Winter* in either of the *frozen Zones*, muſt be alſo ſaid concerning the gaining a whole Day or Week or Month of Daylight at their *Summer*; and thoſe Parts of the Year are all Darkneſs in the *Northern frigid Zone*, which are all Daylight in the *Southern*.

Thus as you go farther *Northward* or *Southward* the Continuance of the Sun above the *Horizon* grows longer in their *Summer*; and the utter Abſence of it below the *Horizon* grows longer in their *Winter*; till you come to thoſe Inhabitants (if any ſuch there be) who live *under the Pole*, for theſe have half the Year Night, and half the Year Day, as I ſaid before concerning the *Parallel Sphere*.

In the two *Temperate Zones* (as alſo in the *Torrid Zone*) there are never quite 24 Hours either of Day or of Night together; but when the Sun is in the *Equator*, all Days and Nights are equal: Afterwards their Days gradually increaſe till their longeſt Day in Summer, and gradually decreaſe till their ſhorteſt Day in Winter: Though thoſe who live on the Borders of the *Polar Circles* or the *Frigid Zones* have their 22d of *June* or longeſt Day in Summer near 24 Hours; and their 22d of *December* or ſhorteſt Day in Winter, but juſt allows the Sun to peep a Moment above the *Horizon*, ſo that their Night is very near 24 Hours long.

*Thirdly*, The Inhabitants of the Earth may alſo be divided into three Sorts in reſpect of their *Geographical Relation* to one another, and they are called the *Periœci*, the *Antœci* and *Antipodes*.

I. The *Periœci* live under the *ſame Parallel of Latitude* on the ſame Side of the Globe, *but differ in Longitude* from Eaſt to Weſt 180 Degrees, or juſt half the Globe. Theſe have their *Summer* and *Winter* at the *ſame* Times with one another, but *Day* and *Night* juſt at contrary Times. *Note*, Thoſe who live under the Poles have no *Periœci*.

II. The *Antœci* live under the ſame *Meridian* or *Line of Longitude*, and have the *ſame Degree of Latitude too*, but on *contrary* Sides of the *Equator*, one to the North, the other to the South. Theſe have *Day* and *Night* exactly at the *ſame* Time, but *Summer* and *Winter contrary* to each other. *Note*, Thoſe who live under the *Equator* have no *Antœci*.

III. The *Antipodes* have (if I may ſo expreſs it) the Properties of the *Antœci* and *Periœci* joined together, for they live on *contrary Sides* of the Equator, though in the ſame Latitude or Diſtance from it; and their

*Meridian* or *Line of Longitude* is 180 Degrees or half the Globe different. A Line paſſing through the Centre of the Earth from the Feet of the one would reach the Feet of the other. They dwell at the full Diſtance of half the Globe, and have *Day* and *Night*, *Summer* and *Winter* at contrary Times.

In each of the three laſt Figures, (*viz.*) VIII, IX and X. you may ſee theſe Diſtinctions of the Earth's Inhabitants exactly repreſented. ♋ A are *Periœci*, ſo are C ♑. But ♋ C or A ♑ are *Antœci*. ♋ ♑, or A C, or N S or H R, or E Q, are all Antipodes to each other.

The *Amphiſcii*, *Heteroſcii* and *Aſcii*, which are only *Greek* Names invented to tell how the Sun caſts the Shadows of the ſeveral Inhabitants of the World, are not worth our preſent Notice.

## SECT. X.

### *The Natural Deſcription of the Earth and Waters on the Terreſtial Globe.*

THE *Earth* may be divided into its *Natural* or its *Political* Parts. The one Diſtinction is made by the God of Nature who created it: The other by Men who inhabit it.

The Globe or Surface of *Earth* on which we dwell is made up *naturally* of two Parts, *Land*

*Land and Water*; and therefore it is called the *Terraqueous Globe.* Each of theſe Elements have their various Parts and Subdiviſions, which are as variouſly deſcribed on *artificial Globes* or *Maps.*

The Land is called either an *Iſland*, a *Continent*, a *Peninſula*, an *Iſthmus*, a *Promontory*, or a *Coaſt.* See the plain Deſcription of all theſe Figure XIII.

An *Iſland* is a *Country* or Portion of Land, compaſſed about with Sea or other Water, as *Great Britain*, *Ireland* in the *Britiſh Seas*; *Sicily*, *Crete*, *Cyprus*, &c. in the *Mediterranean Sea*; the Iſles of *Wight*, of *Angleſy*, of *Man* near *England*: There are alſo Iſlands in Rivers.

A *Continent*, properly ſo called, is a large Quantity of Land in which many great Countries are joined together, and not ſeparated from each other by the Sea, ſuch are *Europe*, *Aſia*, *Africa*. This is ſometimes called the *Main-Land.*

A *Peninſula* is a Part of Land almoſt incompaſſed with Water, or which is almoſt an Iſland: Such is the *Morea* which joins to *Greece*, ſuch is *Denmark* as joining to *Germany*, and *Taurica Cherſoneſus* joining to *Little Tartary* near *Muſcovy*; and indeed *Africa* is but a large *Peninſula* joining to *Aſia.*

An *Iſthmus* is a narrow Neck of Land between two Seas, joining a Peninſula to the Continent, as the Iſthmus of *Darien* or *Panama* which joins *North* and *South America*: The Iſthmus of *Corinth* which joins the *Morea* to *Greece*: The Iſthmus of *Sues* which joins *Africa* to *Aſia*.

A *Promontory* is a Hill or Point of Land ſtretching out into the Sea: It is often called a *Cape*, ſuch is the *Cape of Good Hope* in the South of *Africa*; the *Land's End* and the *Lizard Point* are two Capes at the Weſt of *England*; *Cape Finiſterre* on the Weſt of *Spain*, &c.

A *Coaſt* or *Shore* is all that Land that borders upon the Sea, whether it be in Iſlands or Continents: Whence it comes to paſs that ſailing near the Shore is called *Coaſting*.

That Part of the Land which is far diſtant from the Sea is called the *Inland Country*: Theſe are the Diviſions of the Land.

The *Water* is divided into *Rivers* or *Seas*.

A *River* is a Stream of Water which has uſually its Beginning from a ſmall *Spring* or *Fountain* whence it flows continually without Intermiſſion, and empties itſelf into ſome *Sea*. But the Word *Sea* implies a larger Quantity of Water, and is diſtinguiſhed into *Lakes*, *Gulfs*, *Bays*, *Creeks*, *Straits*, or the *Ocean*.

The *Ocean* or the *Main-Sea* is a vaſt ſpreading Collection of Water, which is not divided or ſeparated by Lands running between:

tween: Such is the *Atlantick* or *Weſtern Ocean* between *Europe* and *America*: The *Eaſtern* or the *Indian Ocean* in the *Eaſt-Indies*: The *Pacifick Ocean* or *South Sea*, on the Weſt Side of *America*, &c.

*Note*, The various Parts of this *Ocean* or *Main-Sea* that border upon the Land are called by the Names of the Lands which lie next to it; So the *Britiſh Sea*, the *Iriſh Sea*, the *Ethiopian Sea*, the *French* and *Spaniſh Seas*.

A *Lake* is a large Place of Water incloſed all round with Land, and having not any viſible and open Communication with the Sea: Such are the *Caſpian Sea* or *Lake* in *Aſia*; the *Lake Zaire* in *Africa*, (as ſome Maps deſcribe) and many others there are in *Europe* and *America*, and eſpecially in *Sweden* and *Finland*, and on the Weſt of *New England*: Such alſo is the Lake or Sea of *Tiberias* in the Land of *Canaan*, and the *Dead Sea* there, which we read of in Scripture.

A *Gulf* is a Part of the Sea that is almoſt incompaſſed with Land, or that runs up a great Way into the Land.

If this be very large it is rather called an *Inland Sea*: Such is the *Baltick Sea* in *Sweden*, and the *Euxine Sea* between *Europe* and *Aſia*; the *Ægean Sea* between *Greece* and *Leſſer Aſia*; and the *Mediterranean Sea* between

tween *Europe* and *Africa*, which is often in the old Teſtament called the *Great Sea.*

If it be a leſs Part of the Sea thus almoſt incloſed between Land, then it is more uſually called a *Gulf* or *Bay:* Such is the *Gulf of Venice* between *Italy* and *Dalmatia:* The *Arabian Gulf* or the *Red Sea* between *Aſia* and *Africa:* The *Perſian Gulf* between *Arabia* and *Perſia:* The Gulf or Bay of *Finland* in the *Baltick* Sea; and the Bay of *Biſcay* between *France* and *Spain.*

If it be but a very ſmall Part, or as it were an *Arm of the Sea* that runs but a few Miles between the Land, it is called a *Creek*, a *Haven*, a *Station*, or a *Road* for Ships; as *Milford Haven* in *Wales*; *Southampton Haven* in *Hampſhire*, and many more in every Maritime Country.

A *Strait* is a narrow Part of the Ocean lying between two Shores, whereby two Seas are joined together, as the *Sound* which is the Paſſage into the *Baltick Sea*, between *Denmark* and *Sweden:* The *Helleſpont* and *Boſphorus*, which are two Paſſages into the *Euxine Sea* between *Romania* and the *Leſſer Aſia:* The *Straits of Dover* between the *Britiſh Channel* and the *German Sea*; and the *Straits of Gibraltar* between the *Atlantick* and the *Mediterranean*, though the whole *Mediterranean Sea* is ſometimes called the *Straits.*

If we compare the various Parts of the *Land* with thoſe of the *Water*, there is a pretty Analogy or Reſemblance of one to the other. The Deſcription of a *Continent* reſembles that of the *Ocean*, the one is a vaſt Tract of Land as the other is of Water. An *Iſland* incompaſſed with Water reſembles a *Lake* incompaſſed with Land. A *Peninſula* of Land is like a *Gulf* or *Inland Sea*. A *Promontory* or *Cape* at Land is like a *Bay* or *Creek* at Sea; and an *Iſthmus*, whereby two Lands are joined, has the ſame Relation to other Parts of the *Earth* as a *Strait* has to the *Sea* or *Ocean*.

Let us now take Notice by what *Figures* the various Parts of *Land* or *Water* are deſcribed in a *Globe* or *Map*, and in what Manner they are repreſented. See Figure XIII.

*Sea* is generally left as an empty Space, except where there are *Rocks*, *Sands*, or *Shelves*, *Currents of Water or Wind*, deſcribed.

*Rocks* are ſometimes made like little pointed Things ſticking up ſharp in the Sea. *Sands* or *Shelves* are denoted by a great Heap of little Points placed in the Shape of thoſe Sands, as they have been found to lie in the Ocean by ſounding or fathoming the Depths. *Currents of Water* are deſcribed by ſeveral long crooked parallel Strokes imitating a Current. The *Courſe of Winds* is repreſented by the Heads of Arrows pointing to that Coaſt toward which the Wind blows.

The *Land* is divided or diſtinguiſhed from the Sea by a thick Shadow made of ſhort ſmall Strokes to repreſent the *Shores* or *Coaſts*, whether of Iſlands or Continents, *&c.* and it is uſually filled with Names of Kingdoms, Provinces, Cities, Towns, Mountains, Foreſts, Rivers, *&c.* which are deſcribed in this Manner, (*viz.*)

*Kingdoms* or *Provinces* are divided from one another by a Row of ſingle Points, and they are often painted or ſtained with diſtinct Colours. *Cities* or *great Towns* are made like little Houſes with a ſmall Circle in the Middle of them. *Leſſer Towns* or *Villages* are marked only by ſuch a ſmall Circle. *Mountains* are imitated in the Form of little riſing Hillocks. *Foreſts* are repreſented by a Collection of little *Trees*. *Small Rivers* are deſcribed by a ſingle, crooked, waving Line; and *larger Rivers* by ſuch a weaving or curling double Line made ſtrong and black. The Mouths of large Rivers, where they empty themſelves into the Sea, are repreſented ſometimes as Currents of Water, by ſeveral parallel crooked Lines.

I ſhould add this alſo, That in Terreſtial Globes you find the *Mariner's Compaſs* figured in ſeveral Parts, and the Lines of it are drawn out to a great Length toward all

Parts of the World on Purpoſe to ſhew how any Part of the Earth or Sea ſtands ſituated with regard to any other Part; and this is called its *Bearing*, by which you may know what Places bear Eaſt, Weſt, North or South from the Place where you are, or at what other immediate Points of the Compaſs they lie. The *North* is generally deſcribed by a *Flower de Luce*, and the *Eaſt* frequently by a *Croſs*.

Globes are generally ſo formed as to have the *North Pole* juſt ſtanding before the Face: Then the *Eaſt* is at the right Hand, and the *Weſt* at the Left: And thus uſually the Names and Words are written to be read from the *Weſt* to the *Eaſt*. This is alſo obſerved in large Maps, and it ſhould be the ſame in ſmall ones; for when a *Map of a Country* is drawn in any other Form, ſo that the *North* does not lie juſt before us, and the *Eaſt* to our right Hand, it gives great Confuſion to the Learner, and ſometimes confounds the Eye and Imagination even of Perſons ſkilled in Geography.

## SECT. XI.

### *Of Maps and Sea Charts.*

THough nothing can repreſent the Heavens or the Earth in their natural Appearances ſo exactly as a Globe, yet the *two Hemiſpheres* either of the Heavens or of the Earth may be repreſented upon a flat or plain Surface, which are generally called *Projections of the Sphere.*

If you ſuppoſe a Globe to be cut in Halves juſt at the Equator, and each Hemiſphere repreſented on a Plane, it is called a *Projection of the Globe upon the Plane of the Equator.* Then, the *Equinoctial Line* will be the Circumference, and the two *Poles* of the World will be the Centres of thoſe two Projections, and all the *Meridian Lines* will be ſo many ſtrait Lines or Semidiameters meeting in the Centre. This is the moſt common Method of repreſenting the *Celeſtial Globe and the Stars.*

If the Globe be cut aſunder at the Horizon of any particular Place and thus repreſented on a Plane, it is called the *Projection on the Plane of the Horizon.* Then the *Zenith* and *Nadir* will be the Centres of thoſe Projections, and the *Horizon* is the Circumference. The two *Poles* will be placed at ſuch a Diſtance from the Circumference as the *Pole* of the World is elevated above the *Horizon* of that Place; and the *Meridian* will be repreſented as curve Lines meeting in the *Pole Point,* excepting only that *Meridian* that paſſes through the *Zenith* which is always a right Line. This is a more uncommon Projection of the

Sphere, though it is much uſed in *Dialling.*

The moſt uſual Way of deſcribing the Earthly Globe on a Plane, or a Map, is to ſuppoſe the Globe cut in Halves about the firſt *Meridian* at the Iſland *Fero* or *Teneriff.* This is a *Projection on the Plane of the Meridian:* Then the *firſt Meridian* will determine the Circumference: The *Pole Points* will ſtand in the upper and lower Parts of that Circle, and the other Meridians will be curve Lines meeting in the *Pole Points,* except that which paſſes through the Centre of the Projection, which is a right Line.

Here the *Equator* will be a ſtrait Line or Diameter croſſing all the *Meridians* at right Angles, and at equal Diſtances from the two *Poles.*

Here the two *Tropics* of *Cancer* and *Capricorn* are drawn at their proper Diſtances of 23 ½ Degrees from the *Equator;* and the two *Polar Circles* at the ſame Diſtance from the *Poles.*

In this Projection the *Ecliptick* is ſometimes a ſtrait Line cutting the Middle of the *Equator* obliquely in each Hemiſphere, and ending where the two *Tropics* meet the *Meridian:* But ſometimes the *Ecliptick* is drawn as a curve Line or an Arch beginning where the *Equator* meets the *Meridian,* and carried upward juſt to touch the *Tropic* of *Can-*

*Cancer* in one Hemiſphere, and downward to touch the *Tropic of Capricorn* in the other.

It is in this Form the Maps of the World are generally drawn in two large Hemiſpheres.

Note here, That it is impoſſible to repreſent a ſpherical Body exactly in its due Proportion upon a Plane; and therefore the Artificial *Meridians* or *Lines of Longitude*, *Parallels* of *Latitude*, &c. are placed at ſuch different Diſtances by certain Rules of Art, and the Degrees marked on them are often unequal; but ſo drawn as may moſt commodiouſly repreſent the Situation of the ſeveral Parts of the Earth with Regard to one another.

The *Meridian* or Circumference of theſe Circles is divided into four Quarters, and each marked with 90 Degrees beginning from the *Equator* and proceeding toward the *Poles*. Theſe Figures or Numbers ſhew the *Latitude* of every Place in the Earth, or its Diſtance from the *Equator*; and at every 10 Degrees there is a *Parallel of Latitude* drawn on Purpoſe to guide and direct the Eye in ſeeking the Latitude of any Place.

The *Equator* of each Hemiſphere is divided into 180 Parts, which makes 360 in the whole: And the ſeveral *Meridians* or *Lines of Longitude*, cutting the *Equator* at every 10 Degrees, guide and direct the Eye to find the Longitude of any Place required.

As the *Equator*, the ſeveral *Lines of Longitude*, of *Latitude*, &c. cannot be repreſented on a Plane exactly as they are on a Globe; ſo neither can the ſeveral Parts of the World, *Kingdoms*, *Provinces*, *Iſlands*, and *Seas* be repreſented in a Map exactly in the ſame Proportion as they ſtand on a Globe. But as the Diviſions of Degrees in a Map are bigger or leſs, ſo the Parts of the Land and Sea are repreſented there bigger or leſs in a moſt exact Proportion to thoſe *Lines of Longitude* and *Latitude* among which they are placed.

Therefore though the Length or Breadth, or Diſtance of Places on a *Map of the World* cannot be meaſured by a Pair of Compaſſes as they may be on a Globe, yet you may count the Number of Degrees to which ſuch Lengths, Breadths or Diſtances correſpond, and thereby you may compute their real Dimenſions; though not always ſo well as on a Globe; of which hereafter.

Thus much ſhall ſuffice concerning *Maps* that repreſent the *Whole World*, or the *Globe of Earth and Water*. Let us next conſider thoſe *Maps* which repreſent particular Parts of the World, *Kingdoms* or *Provinces*, theſe are generally drawn in a large Square, and are to be conſidered as *Parts of a Projection on the Plane of the Meridian*.

From the Top to or toward the Bottom of

the Square are drawn *Meridians* or *Lines of Longitude*; and the Number of Degrees of Longitude are divided and marked on the upper and undermoſt Line of the Square.

From Side to Side are drawn *Parallels of Latitude*, and the Degrees of Latitude are marked on the two Side Lines.

Thus you may eaſily find on a *Map* what is the *Longitude* or *Latitude* of any Place given, or you may find the Point where any Town ſtands or ſhould ſtand, when the true *Longitude* and *Latitude* of it are given.

*Note*, In ſuch Maps of particular Countries the *Longitude* is not always reckoned from the *firſt Meridian*, as *Fero* or *Teneriff*, but oftentimes it is reckoned from the *Chief City* of that Kingdom, which is deſcribed in the Map, as I have intimated before.

*Obſerve* farther, That though in Globes and Maps of the whole World the *Longitude* is reckoned from the *Weſt* toward the *Eaſt*, yet in ſmaller Maps it is often reckoned both Ways, as *Briſtol* is 2 ½ Degrees of Weſtern Longitude from *London*, *Amſterdam* has near 5 *Degrees* of Eaſtern Longitude.

Note alſo, That when a ſmall Country is repreſented in a large Map, the *Lines of Longitude* and *Parallels of Latitude* are drawn not merely at every 10 Degrees, as in the Globe, but ſometimes at every 5 Degrees, and ſometimes at every ſingle Degree.

Let it be obſerved alſo in *large Maps*, that deſcribe any particular Country or Province, as a ſingle or double crooked waving Line ſignifies a *River* when it is made ſtrong and black; ſo a *Publick Road* is deſcribed by a ſingle or a double Line drawn from Town to Town, not quite ſo curled nor ſo ſtrong as a *River* is, but ſtrait or winding as the Road itſelf happens. And where the *Roads* lie through a broad Plain or great Common without Houſes or Hedges, they are ſometimes deſcribed by a *double Row of Points*.

As *Villages* and *ſmaller Towns* are deſcribed by a little Circle or ſmall round o in Maps of larger Countries, where the *Cities* are repreſented by the Figure of a Houſe or two with a Spire or Steeple; ſo in Maps of ſmaller Countries or Provinces the *little Towns* and *Villages* are deſcribed by the Figure of a Houſe or two, and *great Towns* or *Cities* are marked like ſeveral Buildings put together in Proſpect, or elſe the naked Plan of thoſe very Towns or Cities is drawn there and diſtinguiſhed according to their Streets.

I proceed now to conſider *Sea-Charts*.

As *Maps* are drawn to deſcribe particular Countries by Land, ſo a Deſcription of Coaſts or Shores, and of the Seas for the Uſe of Mariners is called a *Sea-Chart*, and it differs from a *Map* chiefly in theſe Particulars.

I. A *Map of the Land* is full of Names and Marks deſcribing all the Towns, Countries, Rivers, Mountains, *&c.* but in a *Sea-Chart* there are ſeldom any Parts of the Land marked or deſcribed, beſides the Coaſts or Shores and the Sea Ports, the Towns or Cities that border upon the Sea, and the Mouths of Rivers.

II. In a *Map* the Sea is left as an empty Space, except where the Lines of Longitude and Latitude, *&c.* are placed: But in *Sea-Charts* all the Sholes or Sands, and ſhallow Waters, are marked exactly according to their Shape, as they have been found to lie in the Sea by ſounding the Depth in every Part of them.

III. In *Sea-Charts*, the Meridians are often drawn in ſtrait and parallel Lines, and the Lines of Latitude are alſo ſtrait Parallels croſſing the Meridians at right Angles. This is called *Mercator's Projection*; and the Points of the Compaſs are frequently repeated and extended through the whole Chart in a Multitude of croſſing Lines *, that whereſoever the Mariner is upon the Sea he may know toward what Point of the Compaſs he muſt ſteer, or direct his Veſſel to carry it toward any particular Port; nd that we may be able to ſee with one Caſt of an Eye the various *Bearings* of any Port, Coaſt, Iſland, Cape, *&c.* toward each other.

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* *See* Marginal Note, Probl. X. Sect. XIX.

IV. The Sea is alſo filled in *Sea-Charts* with various Numbers or Figures which denote the Depth of Water, and ſhew how many Fathom deep the Sea is in thoſe Places where the Number ſtands. Theſe are called *Soundings.*

V. In *Sea-Charts* there is not ſuch Care taken to place the *North* Parts of the World always directly upright and before the Face of the Reader; but the Coaſts and Countries are uſually deſcribed in ſuch a Poſition as may afford the fitteſt Room to bring in the greateſt Variety of Shores and Seas within the Compaſs of the ſame *Chart*, whether the *Eaſt*, or *Weſt*, or *North*, be placed directly before the Reader.

Here let it be noted that as *Geography* taken ſtrictly and properly is a Deſcription of Land, ſo a Deſcription of Water or Sea is called *Hydrography*; and as thoſe who deſcribe the Land on Maps are properly called *Geographers*, ſo thoſe who draw the Sea-Charts are often called *Hydrographers.*

## SECT. XII.

### *The Political Diviſions of the Earth repreſented on the Globe.*

THUS we have finiſhed the *natural Diviſions of the Surface of the Earth*; we come now to conſider how it is divided *Politically* by Men who inhabit it.

In this Senſe it is diſtinguiſhed into four Quarters, into Empires, Kingdoms, States, Commonwealths, Principalities, Dukedoms, Provinces, Counties, Cities, Towns, Villages, *&c.*

The *Earth* is firſt divided into four chief Parts or Quarters, which are called *Europe*, *Aſia*, *Africa*, and *America*.

*Europe* is divided from *Africa* and bounded on the South Side by the *Mediterranean Sea*. On its Eaſtern Side it is divided from *Aſia* by a Line drawn on the Eaſt Side of *Candia* or *Crete* paſſing up the *Ægean Sea* and through the *Propontis* into the *Euxine* or *Black Sea*, and from thence through the Sea of *Zabaique* by the River *Don* or *Tanais*, and thence through *Muſcovy*, (as ſome will have it) to the River *Oby* running into the Northern Ocean. It is alſo bounded on the Weſt Side by the *Weſtern* or *Atlantick Ocean*.

*Aſia* is alſo bounded on the *North* by the Northern frozen Seas: On the South by the *Indian Ocean*: On the Eaſt it includes *China* and the *Oriental Iſlands*: But on the *North Eaſt* its bounds are unknown, for Travellers have not yet been able to determine whether thoſe Eaſtern Parts of *Great Tartary* may not be joined to ſome unknown Parts of *North America*.

*Africa* is a large Peninſula joining to *Aſia* by a little Neck of Land at *Egypt*, bounded on the North by the *Mediterranean Sea:* On the Weſt by the *Atlantick* and *Ethiopick Oceans:* On the North Eaſt by the *Red Sea*; and on the South and Eaſt by the *Southern* and *Indian Oceans.*

*America* was unknown to the Ancients till found out by *Chriſtopher Columbus*, a little above two hundred Years ago. It is called in general the *Weſt-Indies.* It lies almoſt three thouſand Leagues to the Weſtward from *Europe* and *Africa* on the other Side of the *Atlantick* and *Ethiopick Seas:* It is made up of two large Continents, divided by a narrow Neck of Land into two Parts; the one is called *North America* or *Mexicana*, the other *South America* or *Peruana.*

Let us treat briefly of each of theſe in their Order.

## SECT. XIII.

### *Of* EUROPE *and its ſeveral Countries and Kingdoms.*

THE chief Countries of which EUROPE is compoſed may be diſtinguiſhed into the *Northern*, the *Middle*, and the *Southern* Parts.

I. The *Northern* Parts are the *Britiſh Iſles*, *Denmark*, *Norway*, *Sweden*, *Muſcovy*, and *Lapland.*

The *Britiſh Iſles* are *Great Britain* and *Ireland*, *Great Britain* contains the two Kingdoms of *England* and *Scotland*, which were lately united into one. The chief City of *England* is *London*, and *Edinburgh* is the chief in *Scotland*, as *Dublin* is in *Ireland*. *Note*, That *Wales* is reckoned a Part of *England*, though they ſpeak a different Language.

*Denmark* is a ſmall Kingdom on the North of *Germany* made up of one Peninſula, and ſeveral Iſlands in the *Baltick Sea*; its chief City is *Copenhagen*, which ſtands in the largeſt of thoſe Iſlands.

The Kingdom of *Norway* (which lies all along bordering on the Weſt of *Sweden*) has its chief Town *Drontheim*; this together with the Iſle of *Iceland* far diſtant in the Northern Sea is under the Government of the King of *Denmark*.

*Sweden* is one of the Northern Kingdoms which almoſt incompaſſes the *Baltick Sea*: Its chief City is *Stockholm*. That Part of it that lies on the Eaſt Side of the *Baltick* is called *Finland*, *Livonia*, &c. and the Southern Part on the Weſt Side next to *Denmark* is called *Gothland*.

All the North Eaſt Part of *Europe* is *Ruſſia* and *Muſcovy* under the Government of the *Czar*, whoſe Capital City is *Moſcow*. His Conqueſts have lately joined *Livonia* to his Dominion, which before belonged to *Sweden*, and there he has built the City *Peterſburg*.

*Lapland* is a cold ſavage Country that lies on the North of *Sweden*, and belongs to three Princes, (*viz.*) the *Dane*, the *Swede*, and the *Muſcovite*.

*Note*, That *Norway*, *Lapland*, and *Sweden*, were once all comprized under the general Name of *Scandinavia*.

II. The *Middle* Parts of *Europe* are *France*, *Germany*, *Poland*, *Hungary*, and *Little Tartary*.

*France* lies juſt Southward of *England*; its Northern Coaſt is waſhed by the *Engliſh Channel*; its Weſtern Shores by the *Atlantick Sea*; and its Southern by the *Mediterranean*: Its chief City is *Paris*.

Before I proceed to *Germany*, it is proper to mention a long Row of diſtinct Governments which lie on the Eaſt of *France*, and divide it from *Germany* and *Italy*. Theſe are the Seven *United Provinces*, the Ten *Spaniſh Provinces*, the Dukedom of *Lorrain*, the Countries of *Switzerland*, *Savoy*, and *Piedmont*.

The Seven *United Provinces* are called by the Name of *Holland*, becauſe that is the biggeſt of them. They are a moſt conſiderable Commonwealth, and their chief Cities are *Amſterdam*, *Rotterdam*, *Leyden*, *Utrecht*, &c.

Southward of this lie the Ten *Spaniſh Provinces*, or the *Low Countries* or *Netherlands*, which are called by the Name of *Flanders*, becauſe that is the largeſt of them: They have belonged to the Kingdom of *Spain* for ſome Ages; but they are now under the Emperor of *Germany*; their chief Cities are *Bruſſels*, *Antwerp*, *Louvain*, *Mons*, *Namur*, *Ghent*, &c.

*Lorrain* lies to the South of *Flanders*, and is governed by a Duke: Its chief Town is *Nancy*.

*Switzerland* is the next: It is a free Republick divided into thirteen Parts, commonly called the *Swiſs-Cantons*, (viz.) *Zurich*, *Bern*, *Baſil*, *Lucern*, &c. Their Allies are the *Griſons*, the *Valtoline*, &c. The Commonwealth of *Geneva* might alſo be mentioned here, which is a very ſmall but free Sovereignty, and maintains its Rights, becauſe none of its Neighbours will let the others ſeize and poſſeſs it.

The Dukedom of *Savoy* and *Piedmont* borders upon the South of *Switzerland*, and reaches to the *Mediterranean Sea*: Its chief City is *Turin*; its Duke is lately made King of *Sardinia*.

I proceed now to *Germany*, which ſtands in the very Heart of *Europe*; it is called an *Empire*, and its chief City where the Emperor dwells is *Vienna*: But there are in it many leſſer Governments, ſuch as Dukedoms, Marquiſates, Biſhopricks, and ſeveral free Towns or Cities that have ſome Dependence upon the Emperor, but yet are little Sovereignties within themſelves.

The moſt conſiderable of theſe is the Dominion of the Arch-duke of *Auſtria*, who is King of *Bohemia* and *Hungary*, and is generally choſen *Emperor.* The nine Electorates are next in Honour, which are ſo called becauſe their Governors are Electors by whom the Emperor of *Germany* is choſen. Their Names or Titles are theſe. (1.) The Archbiſhop of *Mentz.* (2.) The Archbiſhop of *Triers* or *Treves.* (3.) The Archbiſhop of *Cologn.* (4.) The King of *Bohemia.* (5.) The Duke of *Bavaria.* (6.) The Duke of *Saxony.* (7.) The Marquis of *Brandenburgh*, now King of *Pruſſia.* (8.) The Prince Palatine of the *Rhine.* (9.) The Duke of *Brunſwick* and *Lunenburg*, who is alſo King of *Great Britain.* Beſides all theſe there are many ſmall Principalities governed by Secular or Eccleſiaſtical Powers, which are too numerous to be reckoned up here.

*Poland* is a large Kingdom lying to the Eaſt of *Germany:* It comprehends alſo the large Province of *Lithuania:* The chief Cities of this Kingdom are *Warſaw* and *Cracow.* I might here mention the Country of *Pruſſia*, which ſome Years paſt has been dignified with the Name ef a Kingdom: It is ſituate Northward between *Germany* and *Poland*. The King reſides at *Berlin* in *Brandenburgh.*

*Hungary* is a Kingdom which lies juſt South of *Poland*, its chief Towns are *Preſburg* and *Buda*: It has been in a great Meaſure under the Government of the *Turks*; but it now belongs to the Emperor of *Germany*.

*Little Tartary*, which is alſo called *Crim Tartary*, is a ſmall Country lying to the Eaſt of *Poland*, and ſtretching along on the North Side of the *Euxine* or *Black Sea*.

III. We go on now to the *Southern* Parts of *Europe*; and theſe are *Spain*, *Italy*, and the *European* Dominions of the *Turk*.

*Spain* is the moſt Southern Kingdom of *Europe*, a large Country; its Capital City *Madrid* ſtands in the Midſt of it: On the Weſt Side of it lies the Kingdom of *Portugal* bordering all along upon it; it was once a Part of *Spain*, but now is ſubject to a diſtinct King: Its chief City is *Liſbon*.

*Italy* is a large Peninſula in the *Mediterranean Sea*, and contains various Governments in it, (*viz.*) *Mantua*, *Modena*, *Parma*, *Lucca*, *Genoa*, &c. but the moſt noted and remarkable are theſe five, *Venice*, *Milan*, *Florence* or *Tuſcany*, *Naples*, and the *State of the Church*, which is the Dominion of the Pope, whoſe chief City is *Rome*.

In the South Eaſt Part of *Europe* lies the famous Country of *Greece*, which contains the antient Provinces of *Macedonia*, *Theſſalia*, *Achaia*, &c. with the Towns of *Theſſalonica*, *Philippi*, *Athens*, *Corinth*, &c. and the Peninſula of *Peloponneſus*, now called the *Morea*; but all theſe together with the more Northern Provinces of *Tranſilvania*, *Walachia*, *Bulgaria*, *Romania*, &c. are now almoſt intirely under the Dominion of the *Turk*, whoſe chief City is *Conſtantinople*, ſituate at the Mouth of the *Euxine Sea*. All this is called *Turkey in Europe*.

Thus have we gone through the *Northern* and *Middle*, and *Southern* Countries of *Europe*: But it may be proper to mention alſo ſome of the chief *Iſlands* of this Part of the World, as well as the *Mountains* of *Europe* and its *Rivers*.

Near to *Iitaly*, *France* and *Spain*, lie ſeveral Iſlands in the *Mediterranean Sea*; ſuch as *Majorca*, *Minorca*, *Ivica*, *Corſica*, *Sardinia*, *Sicily* and *Malta*, which belong to different Princes.

On the Eaſt Side of *Greece* is the *Ægean Sea*, or *Archipelago*, in which are mauy ſmall Iſlands, and *Crete* a large one: On the Weſt Side of *Greece* is the *Gulph of Venice*, or the *Adriatick Sea*, in which alſo there are ſeveral ſmall Iſlands, as *Corfu*, *Cephalonia*, *Zant*, &c.

Divers other *Iſles* there are which are included in *Europe*; as the *Iſle of Man*, of *Angleſey*, of *Wight*, *Jerſey*, *Guernſey*, &c. which belong to *England*: The *Hebrides* on the Weſt of *Scotland*, the *Orcades*, and *Schetland* Iſles on the North: Some in the *Baltick Sea*, which belong to *Sweden* and *Denmark*: The *Azores* or Weſtern Iſlands in the *Atlantick Sea*, which are under the King of *Spain*. And ſeveral others of leſs Note.

Some of the moſt remarkable *Mountains* in *Europe* are, (1.) The *Alps* between *France* and *Italy*. (2.) The *Apennine* Hills in *Italy*. (3.) The *Pyrenean* Hills between *France* and *Spain*. (4.) The *Carpathian* Mountains in the South of *Poland*. (5.) The *Peak* in *Derbyſhire* in *England*. (6.) *Plinlimmon* in *Wales*, &c. Beſides ſeveral *Volcano*'s, or Burning Mountains, as *Veſuvius* and *Stromboli* in *Naples*, *Mount Ætna*, now called *Mon-Gibel*, in the Iſland of *Sicily*, and *Mount Hecla* in the cold Iſle of *Iceland*.

The principal *Rivers* of Note in *Europe* are the *Thames* and the *Severn* in *England*; the *Tay* in *Scotland*; the *Shannon* in *Ireland*; *Tagus* in *Portugal* and *Spain*; the *Po* and *Tiber* in *Italy*; the *Weiſel* or *Viſtula* in *Poland*. In *Germany* the *Elbe* and the *Oder*, the *Rhine* and the *Danube*. In *France* the *Sein* and the *Rhone*. In *Moſcovy* the *Don* and the *Volga*.

The *Danube* and the *Volga* are the largeſt Rivers in *Europe*, the *Danube* running through all *Germany* and *Turkey* into the *Euxine* or *Black Sea*; and the *Volga*, (which ſome Writers attribute to *Aſia*, becauſe) though it runs through a great Part of *Moſcovy*, yet it empties itſelf into the *Caſpian Sea.*

## SECT. XIV.

### *Of* ASIA, *and its ſeveral Countries and Kingdoms.*

ASIA may be divided into theſe five Parts, *(viz.) Turkey*, *Perſia*, *India*, *China* and *Tartary*.

The Dominion of the *Turks* in *Aſia* contains ſeveral Countries in it, *(viz.) Natolia*, *Paleſtine*, *Arabia*, *Georgia*, &c.

1. *Natolia*, or *Aſia Minor*, which is a Peninſula between the *Euxine Sea* and the *Mediterranean*, where lay the antient Countries of *Galatia*, *Cappadocia*, *Pontus*, *Bythynia*, *Lyconia*, *Cilicia*, *Phrygia*, *Pamphylia*, &c. through which the Apoſtle *Paul* travelled and made many Converts there. Here were the ſeven famous Churches of *Aſia*, to which the Epiſtles were written in the ſecond and third Chapters of the *Revelations*, *(viz.) Epheſus*, *Smyrna*, *Sardis*, &c. Many of them are now called by different

Names: But *Smyrna* is one of the chief Cities in the whole Country.

2. *Paleſtine*, or the *Holy Land*, and all the adjacent Countries of *Syria*, *Chaldea*, *Meſopotamia*, &c. The chief Towns in it now are *Aleppo*, *Scanderoon*, or *Alexandretta*, *Bagdat* or *Babylon*, *Damaſcus*, *Jeruſalem*, &c.

3. *Arabia*, which antiently was divided into *Arabia* the Happy, *Arabia* the Deſart, and *Arabia* the Stony, lying all between the *Perſian Gulf*, and the *Red Sea*: The chief Towns of it are *Mecca*, *Medina*, &c.

4. *Georgia* and *Turkomania*, formerly called *Armenia Major*, are Northern Provinces belonging to the *Turks*, that lie between the *Euxine* and the *Caſpian* Sea.

*Perſia*, a large Empire, lies Eaſtward from *Turkey* between the *Caſpian* and *Indian Seas*: Its capital City is *Iſpahan*.

*India* is divided in two Parts by the River *Ganges*. *India*, on this Side the *Ganges*, contains the biggeſt Part of the Empire of the *Great Mogul*, whoſe chief City is *Agra*. In a Peninſula or large Promontory in this Part of *India*, are various Settlements of the *European* Nations, as at *Fort St. George*, *Tranquebar*, *Goa*, &c. Beyond the River *Ganges* lies another large Peninſula, which contains the Countries of *Pegu*, *Siam*, *Tunquin*, *Cochinchina*, &c.

Eaſtward of all theſe lies the Empire of *China*, a large and a polite Nation, whoſe chief City is *Pekin*. Theſe countries laſt named are called in general the *Eaſt-Indies*.

*Great Tartary* takes up all the Northern Part of *Aſia*. That which borders upon *Moſcovy* is often called *Moſcovy in Aſia*: The whole is a ſavage, unpoliſhed and unknown Country as to the Parts as well as the Inhabitants of it; and how far it reaches to the *North-Eaſt*, no Man in this Part of the World can inform us.

There are Multitudes of *Iſlands* which belong to *Aſia*, the chief of which are *Japan*, *Borneo*, *Celebes*, *Java*, *Sumatra*, *Ceylon*, the *Philippine Iſles*, the *Maldive Iſles*, &c. all theſe in the *Eaſtern Ocean*, and *Cyprus* in the *Mediterranean*.

The moſt remarkable *Rivers* are *Tigris* and *Euphrates* in *Turkey*, *Ganges* and *Indus* in *India*, whence the whole Country took its firſt Name.

The chief Mountains are *Imaus*, *Caucaſus*, *Ararat*, which are but different Parts of the long Ridge of Hills which runs through *Aſia* from the Weſt to the Eaſt, and is called by the antient general Name of *Mount Taurus*.

SECT.

# SECT. XV.

## *Of* AFRICA *and its Diviſions.*

*AFRICA* is the third Quarter of the World: It may be divided into the following Territories, *Egypt*, *Barbary*, *Bildulgerid*, *Zaara*, *Nigritia*, *Guinea*, *Nubia*, *Abyſſinia* and *Ethiopia*.

*Egypt* lies to the North Eaſt and joins to *Aſia*; the chief Cities are *Grand Cairo* aud *Alexandria*.

*Barbary* is a long Country, it comprehends moſt part of the antient *Mauritania*, or the Country of the *Moors*; it lies along the Coaſt of the *Mediterranean Sea*: Its chief Towns are *Fez*, *Morocco*, *Mechaneſs*, *Sallee*, *Tangeir*, *Ceuta*, *Algier*, *Tunis*, *Tripoli* and *Barca*.

*Bildulgerid*, or the antient *Numidia*, has its chief Town *Dara*; it lies South and South-Eaſt of *Barbary*, unleſs it be reckoned a part of it.

*Zaara* comes next; it is a Deſart Inland Country, and much unknown. So is *Nigritia*, or the Land of the Negroes, which lies to the South of *Zaara*; as *Guinea* is ſituated in the South of *Nigritia*. The *Tooth*, or *Ivory* Coaſt, and the *Quaque* Coaſt, and the *Gold* Coaſt, are ſeveral Diviſions of *Guinea* well known to Mariners.

*Nubia* lies Southward of *Egypt*, as *Abyſſinia* does to the South of *Nubia*, both near the Coaſt of the *Red Sea*.

*Ethiopia* has been given as a general Name to all the Countries that compoſe the South-Eaſt and South Part of *Africa*, at leaſt, all the Maritime Countries or Coaſts from *Guinea*, on the Weſtern Side to *Abyſſinia*, or *Nubia* on the Eaſt, and ſometimes it includes *Abyſſinia* alſo, which is called the *Leſſer* or *Inner Ethiopia*.

In the more Southern Part of *Ethiopia*, are the Inland Kingdoms of *Monomotapa*, *Monoemunga*, &c. On the Weſtern Coaſt *Congo*, *Loango*, *Angola:* The Eaſtern Coaſt is *Zanguebar* and the *Mozambique:* The Southermoſt Coaſt is inhabited by the *Cafres* and the *Hottentots*, near the *Cape of Good Hope*, who are famous for their Stupidity, living in the moſt brutal and barbarous Manner, as though they had little of human Nature in them beſide the Shape.

The chief *Iſlands* near *Africa* are the large Iſle *Madagaſcar*, called the Iſle of *St. Lawrence*, that lies toward the *Eaſtern Sea*; and on the Weſt or North-Weſt are the ſmall Iſlands of *Cape Verd*, the *Canary* Iſlands, and the *Maderas* in the *Atlantick Sea*, with others of leſſer Note in the *Ethiopick Sea*.

The moſt famous *Rivers* in *Africa* are the *Nile* and the *Niger*. The *Nile* runs through all the Eaſtern Part of the Country, and empties itſelf into the *Mediterranean Sea* by many Mouths at the Land of *Egypt*. The River *Senegal*, antiently called *Niger*, runs through *Negroland*, into the *Atlantick Ocean*.

The moſt remarkable *Mountains* are theſe, (1.) *Mount Atlas*, or the *Atlantick* Hills in the Weſt of *Barbary*, which were ſuppoſed by the Antients to be the higheſt in the World; whence came the Fable of *Atlas* a Giant bearing the Heavens upon his Shoulders. (2.) The Mountains of the *Moon*, which lie much more Southward toward *Monomotapa*: And (3.) The exceeding high Hill of *Teneriff*, which is among the *Canary Iſlands*.

## SECT. XVI.

## *Of* AMERICA *and its Diviſions.*

*AMERICA* is the fourth and laſt Quarter of the World, it is divided into the *Northern* and *Southern* Parts by an Iſthmus or Neck of Land at *Darien* or *Panama*.

*Northern America* includes *Canada*, the *Engliſh Empire*, *Old Mexico*, *New Mexico*, *Florida*, and the *Northern Land*.

The *Northern Land* contains ſome Iſlands and Settlements of *European* Nations, in *Hudſon's-Bay* and other Coaſts of *Greenland*, *Greenland*, near to the Arctick Circle, but few of them are much known, frequented or inhabited.

As for the North Weſt Part of *North-America*, it is utterly unknown whether it be Iſland or Continent, whether it may not reach thouſands of Miles farther and be joined to the North-Eaſt Part of *Great Tartary*.

*Canada*, or *New France*, lies on the North-Eaſt Side of the River of St. *Lawrence*, its chief Town is *Quebec*.

The *Engliſh Empire* in *America* lies along the Eaſtern Coaſt from about thirty to almoſt fifty Degrees of North Latitude.

*New England* is the chief Province, of which *Boſton* is the principal Town or City. North of *New England* lies *Acadia*, ſometimes called *New Scotland:* Its chief Town was *Port Royal*, which hath changed its Name to *Annapolis*. Southward of *New England* lie *New York*, *New Jerſey*, *Penſilvania* and *Maryland*, *Virginia* and *Carolina*. On the Weſt and North-Weſt Side of theſe Plantations lie large Tracts of Land with many great Lakes in it, where various Nations of Savages inhabit.

*Florida* comes next in courſe to be mentioned, it borders Eaſt or North-Eaſtward on *Carolina*, and Weſtward it reaches to the River *Miſſiſippi* and beyond it: It is bounded by the Sea on the South, but there have been no very great or remarkable Towns or Settlements formed there by the *Spaniards*, who found and named it.

*New Mexico*, or *New Granada*, lies Weſt of *Florida*, poſſeſſed alſo by the *Spaniards*; its chief Town is St. *Fe*, upon the River *Nort*.

*Mexico*, or *New Spain*, lies more South, it is a large and rich country, long and uneven, ſtretching from North-Weſt to South-Eaſt; and contains many Provinces in it belonging to the *Spaniards*, who have deſtroyed Millions of the Natives there. It has ſeveral Towns, of which the chief has the Name of *Mexico* given it. *Florida* and *Mexico* together make a large Bay, which is called the *Gulf of Florida*, or the *Gulph of Mexico*. This country reaches down to the ſmall Neck of Land whereby *South America* is joined to it. On this Neck of Land are *Panama* on the South Side, and *Porto-Bello*, on the North.

The *Southern Part of America* is ſomething like a large Triangle lying in the vaſt *Southern Ocean*, and almoſt encompaſſed by it: On the Weſtern Side this Ocean is called the *Pacifick Sea*, becauſe ſeldom vexed with Storms.

This *Southern* Part of *America* comprehends many great countries, *viz. Terra Firma, Peru, Amazonia, Guinea, Braſil, Chili, Paraguay, Terra-Magellanica,* &c. The Inland Parts are very much unknown, but the greateſt Part of the Coaſts are poſſeſſed by the Inhabitants derived from *Spain* and *Portugal,* who have made various Settlements there.

The chief *Iſlands* of *America* in the North are *Newfoundland,* which is a Triangle near *Acadia*; then *Cuba, Hiſpaniola,* and *Jamaica,* all in the ſame Climate with *Mexico.* The leſſer Iſles are called *Lucayes,* or *Bahama Iſlands,* South-Eaſt of *Florida*; and the *Caribbee Iſlands* Eaſtward of *Hiſpaniola.* On the Weſt Side of *North America,* lies a very large and long Iſland, called *California,* with many little ones near it.

The chief Iſland in *South America* is *Terra-Delfuego,* which lies near the *Main Land,* and thus makes the *Straits of Magellan.* There are many others of leſs Extent and Note, both on the Coaſt, and in the vaſt *South-Sea.*

The moſt noted *Rivers* of *North America* are the great River of St. *Lawrence,* or *Canada,* that divides *New England* from *New France*; and the River *Miſſiſippi* where the *French* have made large Settlements.

In *South America* the two great Rivers are the *Amazon* with all its Branches, and *Rio dela Plata* or the River of *Plate*.

The chief *Mountains* are the *Apalachin* Hills in *North America*, which divide *Florida* from the more Northern Countries; and the *Andes* in *South America*, which is a long Ridge of Mountains running from the South Part of *America* toward the North: Travellers ſuppoſe them to be the higheſt in the World.

Thus I have deſcribed the various Countries of the Earth in a very brief but imperfect manner, ſufficient only to give the young and ignorant Reader a Taſte of *Geography*, and to encourage him to purſue the Study farther in that excellent Manual *Gordon's Geographical Grammar*, or in Volumes of larger Size.

## SECT. XVII.

### *Of the fixed Stars on the Heavenly Globe.*

AS the *Terreſtrial Globe* has the various Countries, Cities, Mountains, Rivers and Seas drawn upon it: So on the *Celeſtial Globe* are placed the fixed Stars exactly according to their Situation in the Heavens.

Yet there is this Difference between the Repreſentations made by the *Heavenly* and thoſe made by the *Earthly* Globe, *(viz.)* That the ſeveral Countries, Rivers and Seas, are repreſented on the *Convex* or outward Surface of the Earthly Globe, juſt as they lie naturally on the *Convex Surface* of the Earth: Whereas the Stars naturally appear to us in the *Concave*, or inward hollow Surface of the Heaven, but they are repreſented on the Heavenly Globe on the *Convex Surface* of it. Therefore we muſt ſuppoſe our Eye to be placed in the Centre of the Globe, in order to have the Stars and Heavens appear to us in their *Concavity* and proper Situation.

*Planets* and *Comets* are vulgarly called by the general Name of Stars; but the *fixed Stars* differ from the *Planets* and the *Comets* in this, that they always keep the ſame Place or Diſtance with regard to one another; whereas the *Planets* and *Comets* are perpetually changing their Places and Diſtances with Regard to *one another*, and with regard to the *fixed Stars*.

They differ alſo in this reſpect, that the *fixed Stars* generally twinkle, except when near the Zenith, or ſeen thro' a Teleſcope; and they ſhoot ſprightly Beams like the Sun, which is uſually given as a Proof, that like the Sun they ſhine with their own Light: The *Planets* have a more calm Aſpect like the Moon, and never twinkle, which is one Argument among many others that they derive their Light from the Sun, and ſhine only by Reflection.

For our better Acquaintance with the *fixed Stars*, Aſtronomers have reduced them to certain *Conſtellations*. This we have ſhewn already in the ſecond Section, concerning thoſe Stars that lie in the *Zodiack*, which are reduced to 12 Conſtellations, and called the *twelve Signs*, (viz.) *Aries* or the Ram, *Taurus* or the Bull, *Gemini* or the Twins, *&c.* the reſt of the Stars are diſtinguiſhed into the *Northern* and *Southern* Conſtellations, as lying North or South of the *Zodiack* or *Ecliptick*.

The *Northern Conſtellations* were thus framed by the Antients, *Urſa Minor* or the little Bear, in whoſe Tail is the Pole Star, *Urſa Major* or the great Bear, *Draco* or the Dragon, *Cepheus* whoſe Feet are juſt at the North Pole: *Caſſiopeia* and her Chair, *Andromeda*, the Northern *Triangle* *Perſeus* with *Meduſa*'s Head, *Auriga* or the Charioteer, *Bootes* or the Hunter, who is ſometimes called *Arcturus* or the Bear-keeper, *Corona Borealis* or the Northern Crown, *Egonaſi* or *Hercules* Kneeling, *Lyra* or the Harp, *Cygnus* or the Swan, *Pegaſus* or the great flying Horſe, *Equuleus* or *Equiculus* the little Horſe's Head, *Delphinus* or the Dolphin, *Sagitta* or the

Arrow, *Aquila* or the Eagle, which ſome call the Vultur, *Serpens* or the Serpent, and *Serpentarius* the Man who holds it.

To theſe 21 Northern Conſtellations were afterwards added *Antinous* at the Equator next to the Eagle, *Cor Caroli* or King *Charles*'s Heart a ſingle Star South of the *Great Bear*'s Tail, and *Bernice*'s *Hair*, a few ſmall Stars South of *Charles's Heart*, &c.

The *Southern Conſtellations* known to the Antients are *Cetus* the Whale, and the River *Eridanus Lepus* the Hare, the glorious Conſtellation of *Orion* with his Girdle, Sword, and Shield, *Sirius* or the great Dog, *Canicula* or the little Dog, *Hydra* or a large Serpent, the Ship *Argo*, *Crater* or the two handed Cup, *Corvus* the Crow, or the Raven, *Centaurus* or the Half-Man Half-Horſe, *Lupus* or the Wolf, *Ara* or the Altar, *Corona Auſtralis* or Southern Crown, *Piſcis Notius* or the Southern Fiſh.

To theſe 15 there have been added 12 other Conſtellations made up of the fixed Stars toward the South Pole which are never viſible to us in *Britain*, and therefore I ſhall not mention them.

Aſtronomers have framed ſome leſſer *Conſtellations* which are contained in the greater, as the *Pleiades* or the Seven Stars, and the *Hyades* in *Taurus* or the Bull: *Capella* or the Goat, in which is a very bright Star ſo called, in the Arms of *Auriga* or the Charioteer: The *Manger* and *Aſſes* in the *Crab*, which indeed is nothing but a bright Spot compoſed of a Multitude of ſmall Stars: *Charles's Wain* which are ſeven bright Stars in the Rump and Tail of the *Great Bear*, three of which in the Tail reſemble the *Horſes*, and the other four, *c*, *d*, *b*, *r*, a *Square Cart*: See Figure xxx. The two hindmoſt Stars in the *Cart*, (*viz.*) *b* and *r* are called the *Pointers*, becauſe they point to the *North Pole p*.

Beſides theſe there are ſeveral other ſmaller Stars ſcattered up and down in the Heavens, which are not reduced to any of the *Conſtellations*; though of late Years *Hevelius* a great Aſtronomer has made *Conſtellations* of them which are deſcribed upon ſome modern Globes.

The *fixed Stars* are of different Sizes, and are divided into thoſe of the *firſt*, *ſecond*, *third*, *fourth*, *fifth* and *ſixth* Magnitudes.

There are but a few Stars of the *firſt* and *ſecond* Magnitude, and many of them have remarkable Names given to them, as the *Ram's Head*, *Aldebaran* or the Bull's Eye, *Capella* or the Goat, the three Stars in *Orion*'s Girdle, the *Lion's Heart*, *Deneb* or the Lion's Tail, *Regel* the Star in *Orion*'s left Foot, *Spica Virginis*, which is an Ear of Corn in the Virgin's Hand, *Hydra*'s Heart, the *Scorpion's Heart*, the *Eagle* or *Vultur's Heart*, *Ala Pegaſi* or the Horſe's Wing, *Fomahant* a large Star in the Southern *Fiſhes* Mouth near *Aquarius*, the *Pole Star* in the *Little Bear's Tail*, &c. See more in the Table of fixed Stars at the End of this Book.

Some remarkable Stars are called by the Name of the Conſtellation in which they are, as the *Great Dog*, the *Little Dog*, *Lyra* or the Harp, *Arcturus* the Bear-keeper, *Capella* the Goat, *&c.*

As the Globe of the Earth with all the *Lands* and *Seas* deſcribed on a Terreſtrial Sphere is repreſented on *Maps*, ſo the Celeſtial Sphere with all the *fixed Stars* is often repreſented on *two Tables* or *Planiſpheres*, projected, one on the Plane of the Equator with the two Poles of the World in their Centres; and the other on the Plane of the Ecliptic with the Poles of the Ecliptic in their Centres *.

*Note*, This Sort of Projections has ſometimes been furniſhed with ſome little Appendices which are moveable, and makes an Inſtrument called a *Nocturnal* to take the Hour of the Night, and perform many other Aſtronomical Problems by the Stars.

It is hardly neceſſary to ſay, that the Stars are ſuppoſed to keep their conſtant

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* Mr. *Senex* at the Globe over-againſt St. *Dunſtan's* in *Fleet-ſtreet*, has lately printed the beſt that ever were in *England*, or perhaps in any Country.

Revolution once in twenty four Hours by Day as well as by Night: But the Day Light conceals them from our Eyes.

The Sun in its Annual Courſe moving from Weſt to Eaſt through all the *Signs* of the *Zodiack* hides all thoſe Stars from our Sight which are near its own Light or Place in the Heavens; and therefore at ſeveral Seaſons of the Year you ſee different Stars or Conſtellations riſing or ſetting, or upon the Meridian at every Hour of the Night: And as the Sun goes onward daily and monthly toward the Eaſt, the *Eaſtern Conſtellations* come daily and monthly within the Reach of the Sun Beams and are concealed thereby, which is called their *Setting Heliacally*. And the *Weſtern Conſtellations* hereby getting farther off from the Sun Beams, are made viſible to us, which is called *Riſing Heliacally*.

Thus, as I intimated before, we may eaſily find what Stars will be upon the Meridian every Midnight by conſidering in what Sign the Sun is, and in what Degree of that Sign; for the Sun with the Stars that are near it being upon the *Meridian* at *Noon*, the Stars that are directly oppoſite to them in the Heavens will be upon the *Meridian* that Day at *Midnight*. And by the ſame Means if you obſerve what Stars are upon the *Meridian* at *Midnight*, you eaſily infer the Sun is in the oppoſite Point of the Heavens at *Midnoon*.

Here it ſhould not be forgotten, that there is a broad uneven Path incompaſſing the Heavens, paſſing near the *North Pole*, which is brighter than the reſt of the Sky, and may be beſt ſeen in the darkeſt Night; this is called the *Milky Way*, which later Philoſophers have found by their Teleſcopes to be formed by the mingled Rays of innumerable ſmall Stars. It is to the ſame Cauſe that ſome other bright Spots in the Sky (though not all) are aſcribed which appear to us like whitiſh Clouds in Midnight Darkneſs.

## SECT. XVIII.

### *Of the Planets and Comets.*

THOUGH the *Planets* and *Comets* are never painted upon the Globe becauſe they have no certain Place, yet it is neceſſary here to make ſome Mention of them; ſince they are Stars much nearer to us than the *fixed Stars* are, and we know much more of them.

The *Planets* are in themſelves huge dark Bodies which receive their Light from the Sun, and reflect it back to us. They are called *Planets* from a *Greek* Word which ſignifies *Wanderers*, becauſe they are always changing their Places in the Heavens, both with regard to the fixed Stars and with regard to one another.

The *Planets* are placed at very different Diſtances from the Centre of our World, (whether that be the Earth or the Sun) and they make their various Revolutions through the twelve Signs of the *Zodiack* in different Periods of Time.

| | | | |
|---|---|---|---|
| *Saturn* | in 29 Years and | 167 Days, *i. e.* about | 24 Weeks. |
| *Jupiter* | in 11 ——— | 314 ——— | 45 ——— |
| *Mars* | in 1 ——— | 321 ——— | 46 ——— |
| *Earth* or *Sun* | in 1 ——— | 0 ——— | 0 ——— |
| *Venus* | in 0 ——— | 224 ——— | 32 ——— |
| *Mercury* | in 0 ——— | 87 ——— | 12½ ——— |
| *Moon* | in 0 ——— | 27½ ——— | 4 ——— |

As the *Ecliptick* Line is the Orbit or Annual Path of the *Earth* or *Sun*, ſo each *Planet* has its proper Orbit, whoſe Plane differs ſome few Degrees from the Plane of the Orbit of the Sun, and to a Spectator's Eye placed in the Centre would interſect or cut the Sun's Orbit at two oppoſite Points or *Nodes*. Now the Diſtance of a Planet from the Ecliptick, meaſured by an Arch perpendicular to the Ecliptick, is the *Latitude* of that Planet as before.

To repreſent this as in Figure XI. you may imagine as many *Hoops* as there are *Planets* thruſt through with ſeveral ſtrait *Wires*, and thereby joined in different Places to the

*Hoop* that repreſents the Plane of the *Ecliptick*, *i. e.* the Sun's or Earth's Orbit; and then let theſe *Hoops* be turned more or leſs obliquely from the Plane of the *Ecliptick:* For all the ſeveral Orbits or Paths of the *Planets* do not croſs or interſect the *Ecliptick* or *Sun*'s Path in the ſame Point, nor at the ſame Angles: But their *Nodes* or Interſections of the Ecliptick are in different Parts of the *Ecliptick*, and alſo make different Angles with it.

Among the ſeveral Uſes of obſerving the *Latitude* of a Planet, ſee one very neceſſary in *Problem* XXXVII.

The *Comets* were by *Ariſtotle* and his Followers ſuppoſed to be a Sort of *Meteors* or *Fires* formed in the Sky below the Moon, continuing for ſome Months, and then vaniſhing again. But by later Aſtronomers they have been found to be *dark Bodies* like the *Planets*, moving through the Heavens without any Regard to the *Ecliptick*, but in very different Orbits, which are ſuppoſed to be *Ellipſes* or Ovals of prodigious Length, and returning at various Periods of ſeveral ſcores or hundreds of Years. Though it muſt be confeſſed, thoſe Parts of their Orbits which are within the Reach of our Sight are ſo very inconſiderable Parts of the vaſt Ovals they are ſaid to deſcribe, that it has been much doubted, whether the Lines they deſcribe in their Motion be not *Parabolical*, or ſome other infinite Curve; and thus whether the *Comets* themſelves are not *wandering Stars* that have loſt all regular Revolution, and perhaps have no ſettled Periods at all and may never return again: But *Comets* appear ſo ſeldom that they have ſcarce given the nice Enquirers of theſe laſt Ages ſufficient Opportunity to obſerve or calculate their Motions with ſuch an abſolute Certainty as could be wiſhed.

Thus I have finiſhed the ſpeculative Part of this Diſcourſe which contains the *Rudiments* or *firſt Principles of Aſtronomy:* It is called the *Spherical Part*, becauſe it treats of the *Doctrine* and *Uſe of the Sphere*; and I have concluded therein the *general Part of Geography*, and given a ſlight Survey of the *particular* Diviſions of the Earth.

It is indeed the *Second* or *ſpecial Part of Geography* that treats properly of theſe particular Diviſions of the Earth which I have but ſlightly run over, and in a much larger Manner enumerates not only all the Kingdoms, States, and Governments of the World, but alſo gives ſome Account of their Manners, Temper, Religion, Traffick, Manufactures, Occupations, *&c.* It alſo deſcribes the various Towns and Villages, the larger and leſſer Mountains, Rivers, Foreſts, the ſeveral Products of every Country, the Birds, Beaſts, Inſects, Fiſhes, Plants, Herbs, the Soil, Minerals, Metals, and all Rarities of Art and Nature: It relates alſo the various antient and modern Names of the Nations, Cities, Towns, Rivers, Iſlands, *&c.* What remarkable Occurrences of Battles, Victories, Famine, Deſolations, Prodigies, *&c.* has happened in every Nation, and whatſoever has rendered it worthy of publick Notice in the World.

There are many Books extant in the World on this Subject; ſome of leſſer Size, ſuch as *Gordon's Geographical Grammar*, *Chamberlain's Geography*; and larger, (viz.) *Morden's Geography Rectified*, in Quarto, *Theſaurus Geographicus*, *Moll's Geography* in Folio, *&c.*

The *Second* or *Special Part of Aſtronomy* is called the *Theory of the Heavens*, or *the Sun and Planets*, which will lead us into the Knowledge of a thouſand beautiful and entertaining Truths concerning the Syſtem of the World, the various Appearances of the Heavenly Bodies, and the Reaſons of thoſe Appearances, (*viz.*) a more particular and exact Account of the *Day* and *Night*, and of the ſeveral Seaſons of the Year, *Spring*, *Summer*, *Autumn*, and *Winter*, of the *Length* and *Shortneſs* of the Days: Why in the Winter the Sun is nearer to us than it is in the Summer, and why the Winter Half-Year is *ſeven* or *eight Days ſhorter* than the Summer Half-Year: Whence come the *Eclipſes* of the Sun and Moon, both total and partial; why the *Moon* is only eclipſed when ſhe is *full*, and the *Sun* only when ſhe is *New*: Whence proceed the different *Phaſes of the Moon*, as the *New* or *Horned Moon*, the *Half-Moon*, the *Full*, *&c.* Why the two lower Planets *Mercury* and *Venus* always keep near the Sun, and never move ſo far as two whole Signs from it: Why *Venus* is horned, halved and full as the Moon is: Why the three ſuperior Planets *Mars*, *Jupiter* and *Saturn*, appear at all Diſtances from the Sun, and are ſometimes quite oppoſite to it: Why both the *upper* and *lower Planets* ſometimes appear ſwifter, ſometimes ſlower: why they ſeem ſometimes to move directly or forward, ſometimes retrograde or backward, ſometimes are ſtationary, or ſeem to ſtand ſtill: Why they are ſometimes nearer to the Earth, which is called their *Perigeum*, and ſometimes farther from the Earth, which is called their *Apogeum*, and by this Means appear greater or leſs. Why they are nigher to or farther from the Sun, which is called their *Perihelion* and *Aphelion*; and in what Part of their Orbits this Difference falls out: How it comes to paſs that they ſeem higher in the Horizon than really they are by *Refraction*, and how again they ſeem lower than they really are by the *Parallax.*

In this Part of *Aſtronomy* it is proper alſo to ſhew the different *Schemes* or *Hypotheſes* that have been invented to ſolve or explain all theſe Appearances of the Heavenly Bodies. Here the *Ptolemaick* or antient Syſtem ſhould have the firſt Place, to repreſent how the Antients placed the *Earth in the Centre* of the World, and ſuppoſed the Sun to move round it amongſt the other Planets as it appears to the vulgar Eye; and what tedious and bungling Work they made by their Contrivance of *ſolid tranſparent Spheres* of different Thickneſs, placed in *Eccentrick* Order and aſſiſted by their little *Epicycles:* What infinite Embaraſſments and Difficulties attend this rude and ill adjuſted Contrivance, and how impoſſible it is to ſolve all the Appearances of Nature by this *Hypotheſis.*

Then the Modern or *Copernican Scheme* ſhould be repreſented, which makes the Heaven all void, or at leaſt filled only with very fine Ethereal Matter; which places the *Sun in the Centre* of our World with all the *Planets* whirling round it; which makes the *Earth* a Planet, turning *daily* round its own Axis (which is the Axis of the Equator) to form Day and Night;

and

and alſo carried *yearly* round the Sun in the *Ecliptick* between the Orbits of *Venus* and *Mars* to form Summer and Winter. This Scheme alſo makes the *Moon* a *Secondary Planet* rolling *monthly* round the *Earth*, and carried with it in its *yearly Courſe* round the Sun, whereby all the Variety of Appearances of the Sun and Moon, and of all the Planets, as well as the Differences of Day and Night, Summer and Winter, are reſolved and explained with the greateſt Eaſe, and in the moſt natural and ſimple Manner.

Here alſo it ſhould be ſhewn that as the *Moon* is but a *Secondary Planet*, becauſe it moves round the *Earth* which is itſelf a *Planet* : So *Jupiter* which moves round the *Sun* has alſo *four ſecondary Planets* or *Moons* moving round it, which are ſometimes called his *Satellites* or Life-Guards, *Saturn* alſo has *five ſuch Moons*, all which keep their certain Periodical Revolutions: And beſide theſe, *Saturn* is incompaſſed with a large *Flat Ring* 21000 Miles broad, whoſe Edges ſtand inward toward the *Globe of Saturn*, (like a wooden Horizon round a Globe) at about 21000 Miles Diſtance from it, which is the moſt amazing Appearance among all the heavenly Bodies: But theſe *Secondary Planets* which belong to *Jupiter* and *Saturn* together with this admirable *Ring* are viſible only by the Aſſiſtance of Teleſcopes: And yet Mathematicians are arrived at ſo great an Exactneſs in adjuſting the Periods and Diſtances of theſe *Secondary Planets*, that by the Motions and Eclipſes of the *Moons* of *Jupiter* they find not only the true Swiftneſs of the Motion of Light or Sun-beams; but they find alſo the *Difference of Longitude* between two Places on the Earth.

It may be manifeſted here alſo that ſeveral of the *Planets* have their *Revolutions round their own Axis* in certain Periods of Time, as the *Earth* has in 24 Hours; and that they are vaſt bulky dark Bodies, ſome of them much bigger than our Earth, and conſequently fitted for the Dwelling of ſome Creatures; ſo that it is probable they are all *Habitable Worlds* furniſhed with rich Variety of Inhabitants to the Praiſe of their great Creator. Nor is there wanting ſome Proof of this from the Scripture itſelf. For when the Prophet *Iſaiah* tells us, that *God who formed the Earth, created it not in vain,* becauſe *he formed it to be inhabited*, Iſa. xlv. 18. He thereby inſinuates, that had ſuch a Globe as the Earth *never been inhabited*, it had been *created in vain*. Now the ſame Way of Reaſoning may be applied to the other *Planetary Worlds*, ſome of which are ſo much bigger than the Earth is, and their Situations and Motions ſeem to render them as convenient Dwellings for Creatures of ſome Animal and Intellectual Kind.

Many of theſe Things have been performed by ingenious Men with great Exactneſs, for the Uſe of Perſons learned in the Mathematicks; but I know not any ſhort, plain and intelligible Account of them fitted for the Uſe of the unlearned World, except among Dr. *Wells*'s Volumes, intitled, *Mathematicks for a young Gentleman:* Yet I perſuade myſelf, that ſome Parts of it might be performed with greater Eaſe and Clearneſs, in a more natural Method, and to much greater Perfection, if ſome Perſon of peculiar Skill in theſe Sciences and of equal Condeſcenſion would undertake the Work.

## SECT. XIX.

### Problems *relating to Geography and Aſtronomy to be performed by the Globe.*

AS *Theorems* in Mathematick Science are certain Propoſitions declaring ſome *Mathematical Truth:* So a *Problem* is a *Mathematical Queſtion* propoſed to be reſolved, or ſome *Practice* to be performed.

Becauſe this *Problematick Part* will require the Recollection of a great many things in the former Sections, I think it may not be improper to give a ſhort Summary of *Definitions* of the chief Subjects of Diſcourſe in the *Doctrine of the Sphere*, and ſet them in one View.

## DEFINITIONS.

The *Latitude of a Place* on the Earthly Globe, is the Diſtance of the Zenith of that Place from the Equator toward the North or South Pole meaſured by the Degrees of the Meridian.

The *Elevation of the Pole* is the Height of the Pole above the Horizon of that Place meaſured on the Meridian: And it is always the ſame Number of Degrees as the *Latitude*.

The *Longitude of a Place* is the Diſtance of it toward the Eaſt or Weſt from ſome firſt Meridian, and it is meaſured on the Equator.

The *Declination of the Sun* or any *Star* or *Planet* is its Diſtance Northward or Southward from the Equator meaſured on the Meridian. It is the ſame Thing as *Latitude on the Earthly Globe*.

The *Right Aſcenſion* of the Sun is its Diſtance from that Meridian that cuts the Point *Aries* meaſured Eaſtward on the Equator; it is much the ſame with *Longitude on the Earthly Globe*.

The *Hour of the Sun* is its Diſtance from Noon or the Meridian of the Place meaſured on the Equator by 15 Degrees, for every 15 Degrees on the Equator make an Hour. Or it may be reckoned from the oppoſite Meridian or Midnight.

*Note*, The *Right Aſcenſion* is reckoned either in Degrees or in Hours.

The *Latitude of a Star* or *Planet* is its Diſtance Northward or Southward from the Ecliptick: *Note*, The Sun has no *Latitude* becauſe it is always in the Ecliptick.

The *Longitude of the Sun* or *Star* is its Diſtance from the Point *Aries* Eaſtward meaſured on the Ecliptick. But with regard to the Sun or a Planet, this is uſually called the *Place of the Sun* or *Planet* for any particular Day, *i. e.* its Place in the *Zodiack*, or the Degree of the Sign in which it is at that Time.

The *Altitude* or *Height* of the Sun or a Star is its Diſtance from and above the Horizon, meaſured on the Quadrant of Altitudes.

The *Depreſſion* of the Sun or Star is its Diſtance from and below the Horizon.

The *Azimuth* of the Sun or a Star is its Diſtance from the Cardinal Points of Eaſt, Weſt, North or South, meaſured on the Horizon.

The Sun or Stars *Meridian Altitude* is

its Altitude or Height when it is on the Meridian or at the South.

The *Vertical Altitude* of the Sun is uſed by ſome Writers for its Height above the Horizon when it is in the Azimuth or Vertical Circle of Eaſt or Weſt. But the Sun is ſaid *to be Vertical* at any Place when it is in the *Z*enith of that Place at Noon.

The *Amplitude* of the Sun or a Star is its Azimuth or Diſtance from Eaſt or Weſt at riſing or ſetting.

The *Aſcenſional Difference* is the Time of the Sun or Star's riſing or ſetting before or after ſix a Clock: Or it is the Difference between the Sun or Star's ſemidiurnal Arc and a Quadrant or 90 Degrees, as ſome Perſons expreſs it, becauſe 90 Degrees or a Quadrant reaches from 6 a Clock to 12.

## PROBLEMS.

Problem I. *To find the Longitude and Latitude of any Place on the Earthly Globe.*

Turn the Globe about till the Place come juſt under the Side of the brazen Meridian on which the Figures are, which is called its *Graduated Edge*, then the Degree marked on the Meridian juſt over the Place ſhews the *Latitude* either North or South: And the Globe ſo ſtanding, that Degree of the Equator, which is cut by the Meridian ſhews the true *Longitude* of the

Place. So *London* will appear to have 51½ Degrees of North Latitude, and near 18 Degrees of Longitude, counting the firſt Meridian at *Teneriff*. So *Rome* has 41¾ Degrees of North Latitude, and about 13 Degrees of Longitude, Eaſtward from *London*, or almoſt 31 Degrees from *Teneriff*.

Problem II. *The Longitude or Latitude of any Place being given, how to find that Place on a Globe or Map.*

If only the *Latitude* of a Place be given, the Place itſelf may be eaſily found by caſting your Eye Eaſtward and Weſtward along that Parallel of Latitude in that Part of the World where it lies, and the Place (if it be marked on the Globe) will ſoon appear.

If the *Longitude* only were given, guide your Eye along that Meridian Northward or Southward, and you will quickly ſee it.

But if both *Longitude* and *Latitude* be given then the Place is immediately found, for where the given *Line of Longitude* or Meridian cuts the given *Line of Latitude*, there is the Place required. Theſe two Problems alſo may be practiſed on a Map as well as on a Globe.

Problem III. *To find the Diſtance of any two Places on the Earthly Globe, or two Stars on the Heavenly.*

Here let it be noted that a *Degree* of the Meridian or of the Equator, or of any great Circle on the Earthly Globe is found by Meaſure to be 69 ½ or 70 *Engliſh Miles*: See Prob. XII. Sect. XX. Tho' Geographers many times count 60 *Geographical Miles* to a Degree, making them the ſame with the *Minutes* of a Degree for the greater Eaſe in Computation.

Let it be noted alſo, that all the *Degrees* on the Meridians or *Lines of Longitude* on the Globe are equal, becauſe all thoſe Lines are great Circles; but in the *Parallels of Latitude*, the farther you go from the Equator the Circle grows leſs and leſs, and conſequently the *Degrees* of thoſe Circles are leſs alſo: And therefore if two diſtant Places are either both *on the Equator* or have the *ſame Meridian*, the Number of the Degrees of their Diſtance on the Equator or on the Meridian being reduced to Miles ſhews you their true Diſtance: But if the two Places are not both *on the Equator* nor *on the ſame Meridian*, you muſt find their true Diſtance by the following Method.

To perform this *third Problem* lay the Quadrant of Altitude from one Place to the other, and that will ſhew the Number of Degrees of Diſtance, which being multiplied by 60 *Geographical Miles*, or by

70 *Engliſh Miles*, will give the Diſtance ſought.

Or you may take the Diſtance between the two Places with a Pair of Compaſſes and meaſure it upon the Equator, which ſhews the Diſtance in *Degrees*, and then reduce them to *Miles*.

The Quadrant of Altitudes or a Pair of Compaſſes in the ſame Manner, will ſhew the Diſtance of any two Stars on the Heavenly Globe (*viz.*) in Degrees, but not in Miles.

Obſerve here, that though theſe Methods will find the true Diſtance of Places on the *Globe*, yet on a *Map* the ſame Methods are uſeleſs; becauſe in Maps or plain Surfaces the Degrees of Longitude marked on the ſame Parallel of Latitude are unequal, and ſo the Degrees of Latitude marked on the ſame Meridian are often unequal. (See the XI. *Section* concerning *Maps*.) The only Way therefore of meaſuring Diſtances on a Map is to meaſure the Number of Degrees on the neareſt *correſpondent Line of Longitude* or *Latitude*, and apply that to the Diſtance required, which after all is but an uncertain Account.

Problem IV. *To find the* Antœci, Periœci *and* Antipodes *of any Place given*, ſuppoſe of *London*.

Bring *London* to the Meridian, obſerve its Latitude Northward, then reckon ſo many Degrees on the Meridian from the Equator Southward, and it ſhews the Place of the *Antœci.*

Keep *London* under the Meridian, ſet the Hour Index or Pointer on the Dial at the Pole to the upper 12 which is 12 a Clock at Noon, turn the Globe about till the Index point to 12 at Midnight, and the Place that will be under the ſame Degree of the Meridian where *London* was, ſhews where the *Periœci* dwell.

The Globe ſo ſtanding, count the ſame Degrees of Latitude from the Meridian Southward, and that will ſhew who are the *Antipodes* to *London.*

Problem V. *Any Place being given to find all thoſe Places which have the ſame Hour of the Day with that in the given Place.*

All the Places that have the *ſame Longitude* have the *ſame Hour.* Bring the given Place therefore to the Brazen Meridian, and obſerve what Places are then exactly under the graduated Edge of the Meridian, for the People in thoſe Places have the ſame Hour, and their Habitation has the ſame Longitude.

Problem VI. *Any Place being given* (ſuppoſe *Paris*) *to find all thoſe Places in the World which have the ſame Latitude, and conſequently have their Days and Nights of the ſame Length.*

Bring *Paris* to the Meridian, and you find it near 49 Degrees *North Latitude.* Turn the Globe all round, and all thoſe Places which paſs under the 49th Degree of the Meridian have the ſame Latitude with *Paris*, and the Pole is juſt as much elevated above their Horizon, *viz.* 49 Degrees.

Problem VII. *To rectify the Globe according to the Latitude of any given Place.*

Elevate the proper Pole (whether it be North or South) ſo far above the Horizon as is the *Latitude of the Place* propoſed; this is done by moving the Pole of the Globe upward from the Horizon, counting by the Degrees of the under Part of the Meridian, which begin to be numbered from the Pole; thus for *London* you muſt raiſe the Pole 51 ½ Degrees above the Horizon.

Then while *London* ſtands under the Meridian, the true and real Situation of it is exactly repreſented on the Globe with its proper Horizon: For *London* is by this Means placed in the *Zenith*, or on the very Top of the Globe, at 90 Degrees Diſtance from the Horizon every Way; and thus the

*Zenith* is as high *above the Equator* on the South ſide as the *Pole is above the Horizon* on the North ſide.

To render this Repreſentation of the Situation of any Place yet more perfect, 'tis a uſeful thing to have a ſmall *Mariner's Compaſs* at hand with a Needle touch'd with a Loadſtone, to ſhew which are the *North* or *South* Points of the *real Horizon*, and then, as near as you can, ſet the Brazen Meridian of the Globe exactly *North* and *South*.

Thus the *Wooden Horizon* will be a perfect Parallel to the *real Horizon*, the *brazen Meridian* to the real *Meridian*, the *Equator*, the *Ecliptick* and all the *leſſer Circles*, and the *Points* on the Globe will repreſent thoſe Circles and Points on the Earth or in the Heavens, in their proper Poſition.

Problem VIII. *The Hour being given in any Place* (as at *London*) *to find what Hour it is in any other part of the World.*

Rectify the Globe for *London*, bring the City *London* to the ſide of the Meridian where the Degrees are marked; then fix the Index of the Dial-plate to the *Hour* given, (ſuppoſe four a Clock in the Afternoon) this being done turn the Globe and bring any Places ſucceſſively to the Meridian, then the Index or Hour Pointer will ſhew the *true Hour* at the *Place* required. Thus when it is four a Clock in the Afternoon at *London* it is almoſt five at *Rome*, near ſix at *Conſtantinople*, 'tis almoſt half an Hour paſt nine at Night at *Fort St. George* in the *Eaſt-Indies*, 'tis near Midnight at *Pekin* in *China*, 'tis eleven a Clock in the Morning at *Jamaica*, and a little paſt Noon at *Barbadoes*.

Problem IX. *To rectify the Globe for the Zenith.*

After the former Rectification for the *Latitude* of the Place, faſten the Edge of the Nut of the Quadrant of Altitude on its graduated ſide at the proper Degree of Latitude on the graduated ſide of the brazen Meridian, and that will repreſent the *Zenith of that Place* in the Heavens.

The Quadrant of Altitude being thus faſtened ſerves to meaſure the *Sun* or *Star's Altitude* above the Horizon, and the *Sun* or *Star's Azimuth*; and it has been ſometimes (though erroneouſly) uſed to ſhew the *Bearing of one Place to another*, as in the following Problem.

Problem X. *Any two Places being given, to find the Bearing from one to the other, i. e.* at what Point of the Compaſs the one lies in reſpect to the other.

The common Way whereby ſeveral Writers have ſolved this Problem is this. Rectify the Globe both for the *Latitude* and for the *Zenith* of one of thoſe Places, and bring that Place to the Zenith. Then bring down the Edge of the Quadrant of Altitude to the other Place, and the End of the Quadrant ſhall cut the Horizon in the true Point of the Compaſs, and ſhew how the one *bears* to the other. So if you rectify the Globe for the Latitude and Zenith of *Barbadoes*, you will find that *Cape Finiſterre* in *Spain*, and *Azoff* in *Muſcovy*, both lie in a direct Line *North-Eaſt* from *Barbadoes*, according to this Practice.

But here let it be noted, that though according to this Sort of meaſuring, they both lie *North-Eaſt* from *Barbadoes*, yet they do not lie *North-Eaſt* of one another; for if you rectify the Globe for the Latitude and Zenith of *Cape Finiſterre*, you wlll find *Azoff* lies near *Eaſt-North-Eaſt* from *Cape Finiſterre*, or more than two Points of the Compaſs, (*i. e.* more than 22 ½ Degrees different from the *North-Eaſt*.

And if a Sailor or Traveller who is at *Barbadoes*, ſhould every League or Mile of his Way, by obſerving the Compaſs, ſtill make toward the *North-Eaſt*, he would come ſooner to the *Hebrides* or *Weſtern Scots Iſlands* than to *Azoff*, or even to *Cape Finiſterre*. But the Courſe that he muſt really ſteer to come to *Cape Finiſterre* is near *North-Eaſt and by Eaſt:* And if he could ſail all the Way clear to *Azoff* from *Barbadoes*, he muſt ſteer ſtill much *more* to the *Eaſtward:* All which Things ſhew the Miſtake of ſolving this Problem in this Manner.

Perhaps this may be made yet plainer to a Learner, if we name two Places which lie under the ſame Parallel of Latitude, (*viz.*) *Madrid* in *Spain*, and *Pekin* in *China*, Latitude 40. Now theſe muſt always bear directly Eaſt and Weſt from each other. But if you bring *Madrid* to the Zenith, and having fixed there your Quadrant of Altitude, you bend it down to the Horizon, it will not follow the Courſe of the 40th Parallel of Latitude, and lead your Eye to *Pekin*, but to much more Southern Places very far diſtant from *Pekin*, and which have a very different *Bearing*, (*viz.*) to the Iſle of *Ceylon*, &c.

Upon this Account, the beſt Writers call that the *Angle of Poſition* between two Places, which is found by the Quadrant of Altitude thus fixed at the Zenith of any Place, and drawn down to the Horizon: But they deſcribe the *Rhumb* or *Courſe of Bearing from one Place* to the other in a different Manner, (*viz.*) It is that *Point of the Compaſs, toward which any Perſon muſt conſtantly ſail or travel, in order to arrive at the diſtant Place given.* And without all doubt, this is the moſt juſt and exact Account of Things.

Now in order to find this, it is ſufficient for a Learner to know, that if any one of the Lines drawn from the Points of the *Mariner's Compaſs* marked on the Globe, (which are called *Rhumb Lines*) paſſes through both Places, that Line ſhews *the Courſe or Bearing from one to the other*, as the Courſe from *Cape St. Vincent* in *Portugal, to Cat Iſland* among the *Bahamia Iſlands*, is *Weſt and by South.*

If no *Rhumb Lines* paſs through thoſe Places, then that *Rhumb Line* to which thoſe two Places lie moſt parallel, ſhews their Bearing: Thus the Courſe from *Barbadoes* to *Cape Finiſterre* is *North-Eaſt and by Eaſt*, or thereabouts.

If the Learner has a Mind to ſee the Reaſon, why there muſt be ſuch a Difference betwixt the *Angle of Poſition* between two Places, and their *Courſe of Bearing* to each other, I know not how to repreſent it upon a flat Surface plainer than by Figure XXI.

Suppoſe the four Cardinal Points, *North, South, Eaſt,* and *Weſt*, are repreſented on the Globe by the Letters N. S. W. E: Suppoſe three diſtant Places are B *Barbadoes*, C *Cape Finiſterre*, and A *Azoff.* If the Surface of the Earth were not Spherical, but a Plane, and the *Meridians* of theſe Places were all parallel (as in that Repreſentation or Projection of the Globe, which is called *Mercator's Chart*) then their *Angle of Poſition* and their *Courſe of Bearing* would be the ſame: Then as N S is the Meridian of the Place B, ſo *q u* would be the Meridian of the Place C, (*viz.*) a ſtrait Line and parallel to N S: Then the Line B C A would be the Line or Rhumb of *North-Eaſt*, (*viz.*) 45 Degrees diſtant from N S; which would repreſent both the *Angle of Poſition* and the *Courſe of Bearing* between all the three Places B, C and A: For the Angle *q* C A would be the ſame with the Angle N B A; and thus A would ſtill bear *North-Eaſt* from C and from B *.

But the Earth being of a Spherical Figure and the Meridians meeting in the Poles, the Meridian of B on the Globe being brought to the Zenith is N S; the Meridian of C is the Curve Line N C *m*; and the Meridian of A is the Curve Line N A Z; all which meet in N the North Pole. Now though the ſtrait Line B C A ſhews the *Angle of Poſition* between the three Places B, C and A, (as B ſtands on the Globe at the Zenith) yet the Line B C A does by no means make the *ſame Angles*, or has the *ſame Bearing* with the Curve Line N C *m* (which is the Meridian of C) as it does with N S (which is the Meridian of B:) and it ſtill makes more different Angles with the Curve Line N A Z (which is the Meridian of A.)

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* And for this Reaſon in thoſe Sea Charts where the Points of the Compaſs or Rhumbs are drawn in ſtrait Lines quite through the Chart, the Meridians or Lines of Longitude are all made ſtrait and parallel Lines: For if the Meridians were a little curved as they are commonly in Maps, the Rhumbs could not be drawn through the Chart in ſtrait Lines. See *Sect.* XI. *Of Sea Charts*, pag. 68.

Thence it follows, that all the *Rhumb Lines* muſt be a Sort of Spiral Lines on the Globe, except the *North* and *South*, which is the *Meridian*, and the *Equator* with its Parallels of *Eaſt* and *Weſt*, which are Circles *.

The *North-Eaſt* Line in this Place muſt be B P *x* ſtill gradually inclining toward the ſeveral Meridians, that ſo it may make the *ſame Angles* with the Meridians N C *m* and N A Z, as it does with N B S.

But by this Means you ſee, that to ſteer or travel ſtill to the *North-Eaſt* would bring you down to P and *x*, not to C and A.

You ſee alſo, that the Courſe you muſt ſteer or travel to come to A will be repreſented by the Line B r A, which is much nearer the *Eaſt Point*.

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* All the other Lines of *Eaſt* and *Weſt* beſides the *Equator*, are Parallels of Latitude, and are leſſer Circles. And though the Line of *Eaſt* and *Weſt* in this Figure, be for the Eaſe of a young Learner repreſented in a ſtrait Line, becauſe it is a Parallel to the *Equator*, and if drawn round the Globe would be a perfect Circle and run into itſelf, yet it ſhould more properly be ſo far curved, as to cut all the *Side-Meridians* N *m* and N Z at right Angles, as well as the Meridian of the Place N S. And thus they are commonly drawn in Maps of the World, wherein there is no Line of *Eaſt* and *Weſt* drawn ſtrait beſides the Equator.

But this is ſomething too laborious and painful for every Reader to trouble his Thoughts with it.

Problem XI. *Having the Day of the Month given, to find the Sun's Place in the Ecliptick.*

Find the Day of the Month in the Calendar on the Horizon, (either Old Stile or New, which ſoever is required) lay a flat Rule on the Day of the Month, and over againſt it on the inner Edge of the Horizon, will appear both the Sign in which the Sun is, and the Degree of that Sign, as on the 10th of *May* Old Stile, the Sun is juſt entering into the *firſt Degree of Gemini*, which you may find in both the Globes on the Ecliptick Circle; and there you may alſo compute the Longitude of the Sun from the Point *Aries* if you pleaſe.

Problem XII. *The Day of the Month being given, to find thoſe Places of the Globe where the Sun will be Vertical or in the Zenith that Day.*

Find out the Sun's Place in the *Ecliptick Circle*; bring it to the Meridian; mark the Degree over it; then turn the Globe round, and all thoſe Places that paſs under that Degree will have the Sun in their *Zenith* that Day.

Problem XIII. *The Day and Hour of the Day at one Place,* (viz.) London *being given, to find at what other Place the Sun is Vertical at that Hour.*

The Sun's Place for that Day being brought to the Meridian, and the Degree over it, (*i. e.* the Declination) being obſerved, bring the firſt Place, *i. e. London* to the Meridian: Set the Hour Index to the given Hour; and turn the Globe till the Index come to the upper 12, (that is 12 at Noon) then the Place of the Earth that ſtands under the obſerved Degree of the Meridian, has the Sun at that Moment in the *Zenith.*

Problem XIV. *The Day and Hour at one Place,* (viz.) London *being given, to find all thoſe Places of the Earth where the Sun is then riſing, ſetting, or on the Meridian, (which is called* culminating) *alſo where it is Daylight, Twilight, or dark Night.*

By the foregoing Problem, find the Place where the Sun is Vertical at the Hour given: Rectify the Globe for the Latitude of that Place; bring that Place to the Meridian.

Then all thoſe Places that are in the *Weſt* Semi-Circle of the Horizon have the *Sun riſing,* for it is 90 Degrees from their *Zenith.*

Thoſe in the *Eaſt* Semi-Circle of the Horizon have it *ſetting,* for it is 90 Degrees paſt their *Zenith.*

To thoſe who live under the ſame Line of Longitude or Upper-Meridian, it is *Noon*, if they have any Day at that Time.

To thoſe who live under the oppoſite Line of Longitude or lower Meridian, it is *Midnight*, if they have any Night at that Time.

Thoſe Places that are above the Horizon, have the *Sun above their Horizon* ſo many Degrees, as the Places themſelves are.

Thoſe Places that are under the Horizon, but within 18 Degrees, have *Twilight*.

And with thoſe who are lower than 18 Degrees, it is *dark Night*.

Problem XV. *A Place being given in the Torrid Zone, to find thoſe two Days in which the Sun ſhall be Vertical there.*

Bring the Place to the Meridian; mark the Degree over it, which is its *Latitude*; move the Globe round, and obſerve theſe two oppoſite Points of the Ecliptick, that paſs through the aforeſaid Degree; ſearch on the Wooden Horizon on what two Days the Sun paſſes through thoſe two Points of the Ecliptick, for then the Sun at Noon will be in the *Zenith of the Place* given.

Problem XVI. *A Place being given in one of the Frigid Zones,* (ſuppoſe the *North*) *to find when the Sun begins to depart from, or to appear on that Place, how long he is abſent, and how long he ſhines conſtantly upon it.*

Suppoſe the Place given be the North *Cape of Lapland* 71 Degrees of Latitude. Rectify the Globe for that Place, or elevate the Pole 71 Degrees; then turn the Globe till the deſcending Part of the Ecliptick, the Meridian and South Point of the Horizon meet together: Thus the Ecliptick will ſhew, that the Sun toward the *End of Scorpio* (that is, a little after the *Middle of November*,) goes below the Horizon intirely and leaves that Part of *Lapland*.

Then turn the Globe a little further, till the aſcending Part of the Ecliptick meet the Meridian in the ſame South Point of the Horizon, and it will ſhew that about the ninth or tenth Degree of *Aquarius*, that is, about the *End of January*, the Sun begins to riſe above their Horizon. Thus they are at leaſt two Months without the Sun in *Winter*.

In like Manner bring the aſcending Part of the Ecliptick to meet the Meridian in the North Point of the Horizon, there you will find that the Sun begins to be entirely above their Horizon toward the End of *Taurus*, or near the *Middle of May*; and if you turn the Globe a little farther, the deſcending Ecliptick will meet the Meridian and Horizon in the North at the 8th or 9th Degree of *Leo*, or about the *Beginning of Auguſt*: Thus it appears that thoſe *Laplanders* will have the Sun at leaſt two Months above their Horizon in Summer, or two Months of compleat Day-light.

Problem XVII. *To find the Sun's Declination and Right Aſcenſion any Day in the Year:* Suppoſe the twenty-firſt of *May.*

Find out the Sun's Place for that Day, or the beginning of the firſt Degree of *Gemini* on the Ecliptick; bring that Point of the Ecliptick to the Meridian, and the Degrees numbered on the Meridian will ſhew the *Sun's Declination,* (*viz.*) 20 Degrees Northward.

At the ſame Time the Place where the Meridian cuts the Equator will ſhew the *Right Aſcenſion of the Sun,* or its Diſtance from the Point *Aries* on the Equator, (*viz.*) 58 Degrees. It is marked uſually in Degrees on the Globe; if you would turn it into Hours, divide it by 15, and it amounts to three Hours $\frac{13}{15}$ which is 52 Minutes.

*Note,* That any *Star's Declination* and *Right Aſcenſion* are found the ſame Way by bringing it to the Meridian.

Remember the Sun's Declination is always *North* in our Summer Half-Year from the 21ſt of *March,* and *Southward* in our Winter Half-Year from the 23d of *September.*

Problem XVIII. *To rectify the Globe for the Sun's Place, any Day in the Year, and thus to repreſent the Face of the Heavens for that Day.*

Bring the Sun's Place found on the Ecliptick of the Globe to the Meridian; and at the ſame time ſet the Hour-Index or Pointer of the Dial to the upper 12, that is, to *Noon.*

*Note*, When the Globe is thus rectified for the *Latitude* of the particular Town or City by Problem 7th, and for the *Zenith* of it by Problem 9th, and for the *Sun's Place in the Ecliptick* that Day by this Problem 18th, it is then fitted to reſolve moſt of the following Problems, for then it moſt exactly repreſents the real Face and State of the Heavens for that Day.

Here let it be obſerved, that this Practice does really repreſent the Face of the Heavens only for that Day at *Noon*, (when the Aſtronomers Day begins) and not for all the following Hours of the Day; becauſe the Sun is every Moment changing his Place a little in the Ecliptick. But it is cuſtomary, and it is ſufficient for Learners, to make this go for a Repreſentation of the Heavens for all that Day, to perform any common Operations.

Problem XIX. *The Place and Day being given,* (viz. *May* 10th at *London*) *to find at what Hour the Sun riſes or ſets, his aſcenſional Difference, his Amplitude, the Length of Day and Night.*

Rectify for the *Latitude*, and for the *Sun's Place*, then bring the Sun's Place down to the *Eaſtern* Part of the Horizon, and the Index will ſhew the Time of *Sun riſe* on the Dial, (*viz.*) five Minutes after four in the Morning. Bring the Sun's Place to the *Weſtern* Side of the Horizon, and the Dial will ſhew the Hour of *Sun ſetting*, (viz.) five Minutes before eight at Night.

Thus his *Aſcenſional Difference* will appear, that is, how long he riſes or ſets before or after ſix a Clock, which is one Hour and 55 Minutes.

Thus alſo his *Amplitude* will appear in the Horizon to be almoſt 34 Degrees to the *North of the Eaſt.*

The Hour of the *Sun's riſing* doubled gives the *Length of the Night*, (viz.) eight Hours and 10 Minutes; and the Hour of the *Sun's ſetting* doubled gives the *Length of the Day*, which will be 16 Hours wanting 10 Minutes, *i. e.* 15 Hours 50 Minutes.

Problem XX. *The Place and Day being given, to find the Altitude of the Sun at any given Hour.*

Rectify for the *Latitude*, for the *Zenith* and for the *Sun's Place:* Bring the Quadrant of Altitude under the Meridian, and it will meet the Sun's Place in the Meridian Altitude of the Sun that Day, and thus ſhew how high it is at *Noon.*

Turn the Globe till the Index point to any other given Hour on the Dial, then obſerve where the Sun's Place is, bring the Quadrant of Altitude to it, and it will ſhew the Sun's Altitude at *that Hour:* Thus *May* 10th at *London*, the Sun's Meridian Altitude will be a little above 58 ½ Degrees, and at 9 a Clock in the Morning will be 43 ¼.

Problem XXI. *The Place and Day being given, to find the Azimuth of the Sun at any given Hour.*

Rectify the Globe for the *Latitude*, the *Zenith* and the *Sun's Place:* Then turn the Globe till the Index point to the Hour given; then obſerve the Sun's Place; bring the Edge of the Quadrant of Altitude down upon it, and it will cut the Horizon in the *Azimuth of the Sun*, or ſhew what Point of the Compaſs the Sun is in. Thus *May* 10th at 20 Minutes paſt 9 in the Morning, the Sun's *Azimuth* will be about 60 Degrees from the *South toward the Eaſt*, that is, near *South-Eaſt and by Eaſt.*

Problem XXII. *The Sun's Altitude being given at any certain Place and Day, to find the Hour of the Day, and alſo his Azimuth.*

Rectify as before for the *Latitude*, the *Zenith* and the *Sun's Place:* Turn the Globe, and move the Quadrant of Altitudes ſo that the Sun's Place may meet the Degree of Altitude given on the Quadrant, then the *Index* will ſhew the *Hour* on the Dial; and the Quadrant of Altitude will cut the *Azimuth* on the *Horizon*. Thus *May* 10th in the Morning, if the *Altitude* be near 46 Degrees the *Azimuth* from the South will be 60, and the *Hour* 26 Minutes paſt 9.

Here *Note*, That to find the *Sun's Hour* or *Azimuth* by his *Altitude*, you ſhould never ſeek it too near Noon, becauſe then the *Altitude* alters ſo very little for two Hours together.

Problem XXIII. *When the Sun is due Eaſt or Weſt in Summer, how to find the Hour, and his Altitude.*

Rectify as before; then bring the Quadrant to cut the *Eaſt* or *Weſt* Point of the Horizon, and turn the Globe till the Sun's Place in the Ecliptick meet the Edge of the Quadrant. Thus the Quadrant will ſhew the *Altitude*, and the Index will point to the *Hour*: Thus *May* 10th in the Afternoon, the Sun will be *due Weſt* at about 56 Minutes paſt 4; and its *Altitude* will be near 26 Degrees. This is called the *Vertical Altitude* by ſome Writers.

Thus if the Place and Day be known, and either the *Hour*, the *Azimuth*, or the *Altitude* be given, you may eaſily find the other two.

Problem XXIV. *To find the Degree of the Depreſſion of the Sun below the Horizon, or its Azimuth at any given Hour of the Night.*

Obſerve the Place of the Sun, ſuppoſe *May* 21ſt in the firſt Degree of *Gemini*, then ſeek his oppoſite Place in the Ecliptick at half a Year's Diſtance, (*viz.*) the firſt Degree of *Sagittary* on the 23d of *November*; this being done, ſeek the *Altitudes*, the *Azimuths*, and the *Hours* juſt as you pleaſe for that Day, and they will ſhew you what are the Sun's *Depreſſions*, *Azimuths*, and *Hours*, on the 21ſt of *May* at Night *.

Problem XXV. *To find how long the Twilight continues in any given Place and given Day, ſuppoſe the* 21ſt *of* May *at* London, *both at Morning and Evening.*

The Way to anſwer this Queſtion is to ſeek how many Hours or Minutes it will be after Sun ſet, before the Sun be depreſt 18 Degrees below the Horizon in that Place on the 21ſt of *May*: And ſo before Sun riſe for the Morning Twilight. This is beſt performed by ſeeking how long it will be after *Sun riſe* or before *Sun ſet* on the 23d of *November*, that the Sun will have 18 Degrees of Altitude, which is done by the foregoing Problem.

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* *Note*, The Reaſon why we uſe the oppoſite Part of the Globe, to find the Degrees of *Depreſſion* of the Sun, is becauſe the *Wooden Horizon* is ſo thick, that we cannot conveniently ſee, obſerve, or compute the Diſtances of Depreſſion from the upper Edge of it, which Edge is the true Repreſentative of the real *Horizon*.

*Note*, That from the 26th of *May* to the 18th of *July* at *London*, there is no *dark Night*, but conſtant *Twilight*: For during this Space the Sun is never depreſt above 18 Degrees below the Horizon.

Problem XXVI. *To know by the Globe the Length of the longeſt and ſhorteſt Days and Nights in any Place of the World.*

Remember that the Sun enters the firſt Degree of *Cancer* on the longeſt Day, at all Places on the *North* Side of the Equator, and the firſt Degree of *Capricorn* on the *South* Side: Alſo remember that he enters the firſt Degree of *Capricorn*, the ſhorteſt Day in all Places of the *Northern* Hemiſphere, and the firſt Degree of *Cancer* in the *Southern*: Then rectify the Globe for the *Latitude* and *Sun's Place*, and find the Hour of *Sun riſing*, which doubled ſhews the Length of the Night: And the Hour of the *Sun ſetting* doubled, ſhews the Length of the Day, as in Problem XIX.

Problem XXVII. *The Declination and Meridian Altitude of the Sun, or of any Star,*

*Star being given, to find the Latitude of the Place.*

Mark the Point of *Declination* on the Meridian, as it is either *North* or *South* from the *Equator*; then ſlide the Meridian up and down in the Notches, till the Point of Declination be ſo far diſtant from the Horizon as is the given *Meridian Altitude.* Then is the Pole elevated to the Latitude ſought.

Thus where the Sun or any Star's *Meridian Altitude* is 58 ½ Degrees, and its *Declination* 20 Degrees *Northward,* the *Latitude* of that Place will be 51 ½ Degrees North. See more *Problem* VII, VIII, IX. *Sect.* XX.

*Note,* There are ſome few *Problems* which relate to the Sun and to the Hour, which may be performed on the Globe when the Sun ſhines, though not with any great Exactneſs, yet ſufficient for Demonſtration of the Reaſon of them as follows.

Problem XXVIII. *The Latitude of a Place being given, to find the Hour of the Day in the Summer when the Sun ſhines.*

Set the Frame of the Globe upon a Plane perfectly Level or Horizontal, and ſet the Meridian due North and South; both which are difficult to be done exactly; even though you have a *Mariner's Compaſs* by you:

Then

Then rectify the Globe for the Latitude, and the iron Pin of the Pole will caſt a Shadow on the Dial and ſhew the *true Hour.* For when the Globe is thus placed, the Dial Plate with the Pole in the Centre of it, is a true *Equinoctial Dial* for our *Summer Half-Year*, when the Sun is on the North Side of the Equator.

The ſame may be alſo done in the *Winter Half-Year*, by depreſſing the North Pole as much below the South Part of the Horizon as is equal to the Latitude of the Place; for then the *Dial Plate* is a proper *Equinoctial Dial* for the Winter Half-Year: But this is not ſo commodiouſly performed, though the Reaſon of it is the ſame as the former.

Problem XXIX. *To find the Sun's Altitude, when it ſhines, by the Globe.*

Set the Frame of the Globe truly Horizontal or Level; turn the North Pole to the Sun; move the Meridian up and down in the Notches till the Axis caſt no Shadow; for then it points exactly to the Sun, and then the Arch of the Meridian between the Pole and the Horizon ſhews the *Sun's Altitude.*

Problem XXX. *The Latitude and Day of the Month being given, to find the Hour of the Day when the Sun ſhines.*

Let the Globe ſtand on a Level, and the Meridian due North and South; rectify the Globe for the *Latitude* and for the *Sun's Place*; ſtick a Needle perpendicular to the Sun's Place on the Globe; turn the Globe about till the Needle point directly toward the Sun, and caſt no Shadow; then will the *Index* ſhew the Hour of the Day.

I proceed now to ſhew ſome *Problems to be performed by the Stars* upon the Heavenly Globe.

Problem XXXI. *The Place being given, to find what Stars never riſe or never ſet in that Place.*

Rectify the Globe for the *Latitude*; turn it round, and obſerve that ſuch Stars as do not go under the Horizon during its whole Revolution, do never ſet in the Place given; and ſuch Stars as riſe not above the Horizon of the Globe during its whole Revolution, they never riſe in the Place given, nor are ever ſeen by the Inhabitants thereof: So the *little Bear*, the *Dragon*, *Cepheus*, *Caſſiopea* and the *great Bear* never ſet at *London*, and many of the *Southern Conſtellations* never riſe.

Problem XXXII. *The Place and Day of the Month being given, to repreſent the Face or Appearance of the Heavens and ſhew the*

*Situation of all the fixed Stars at any Hour of the Night.*

Set the Globe exactly North and South: Rectify it for the *Latitude*, and for the *Sun's Place*; then turn the Globe till the Index points to the given Hour. Thus every Star on the Globe will exactly anſwer the Appearance of the Stars in the Heavens; and you may ſee what Stars are near or on the Meridian, which are riſing or ſetting, which are on the Eaſt or Weſt Side of the Heavens. Thus *October* 13th at 10 a Clock at Night, the glorious Conſtellation *Orion* will appear on the Eaſt Side at *London*, the Star *Regel* in the left Knee (or Foot) of *Orion* juſt above the Horizon, the *three Stars* in his *Girdle* a little higher, &c. This repreſents the Face of the Heavens at Night, as *Problem* XVIII does in the Day.

*Note*, This Problem is of excellent Uſe to find out and know the ſeveral Conſtellations, and the more remarkable Stars in each Conſtellation.

Here follow ſeveral *Problems* to find the *Hour of the Night* by the Stars.

### Problem XXXIII. *Any Star on the Meridian being given, to find the Hour of the Night.*

In order to find what Stars are *upon the Meridian* at any Time, it is good to have a Me-a *Meridian Line* drawn both in a North and in a South Window; that is, a *Line pointing exactly to the North and South:* Then ſet up a broad ſmooth Board of 20 or 24 Inches high, and 8 or 10 Inches broad; place it perpendicular on the Window with its lower Edge on, or parallel to the Meridian Line; and fixing your Eye at the upright neareſt Edge of the Board, and glancing along the plain Face of it, you will eaſily obſerve what Stars are on the Meridian, either North or South at that Time *.

Having found what Star is on the Meridian, rectify the Globe for the *Latitude*, and for the *Sun's Place* that Day; then bring the Centre of the Star which is on the Meridian in the Heavens to the Edge of the brazen Meridian of the Globe; and the Index will ſhew *the Time of Night* on the North Side of the Dial among the Evening, or Midnight, or early Morning Hours.

*Note*, How to draw a Meridian Line, ſee *Sect.* XX. *Problem* XXII, &c.

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* *Note*, To ſet the Board perpendicular and convenient, it is fit to have a Foot made to it behind, that it may ſtand firm. And let a ſtrait Line be drawn from the Top to the Bottom of the Board, through the Middle of it, parallel to the Sides: Fix alſo a Pin in the upper Part of this Line, near the Top of this upright Board, on which hang a Thread and Plummet, to play looſe in a Hole near the Bottom, to keep it perpendicular. Then the Thread hanging almoſt cloſe to the Board will direct your Eye to the Stars on the Meridian.

Problem XXXIV. *The Azimuth of any known Star being given, to find the Time of Night.*

The Method I juſt before propoſed, will eaſily find the *Azimuth* of any Star. Set this tall flat Board perpendicular on the Window, with one End of it upon the *Meridian Line* drawn there, ſo as that your Eye may juſt ſee the Star in the very Edge of the Plane of this Board; then a Line drawn on the Window by the Foot of the Board will croſs the Meridian Line in the *true Angle of its Azimuth*, or its Diſtance from North to South.

Having found the Azimuth of the Star, rectify the Globe for the *Latitude*, and for the *Sun's Place* as before; rectify it alſo for the *Zenith*, and bring the Quadrant of Altitude to the Azimuth of the Star in the Horizon; then turn the Globe till the graduated Edge of the Quadrant of Altitude cut the Centre of that Star, and the Index will ſhew the *Hour of the Night* upon the Dial Plate.

*Note*, That if you have a Meridian Line drawn on a Window, you may find by ſuch Methods as theſe when the Sun is in the Meridian, and what is its Azimuth at any Time.

Problem XXXV. *The Altitude of a Star being given, to find the Hour of the Night.*

*Note*, That the Altitude of the Star muſt be found by a Quadrant or ſome ſuch Inſtrument: But remember that if you would find the Hour by the Altitude of a Star, you muſt never chooſe a Star that is too near the Meridian; becauſe for almoſt two Hours together, the Altitude varies very little when it is near the Meridian.

Rectify the Globe as before for *Latitude*, *Zenith* and *Sun's Place*; move the Globe and the Quadrant of Altitude backward or forward, till the Centre of that Star meet the Quadrant of Altitude in the Degree of Altitude which is given, then the Index will point to the *true Hour*.

*Note*, Theſe three laſt Problems being well underſtood, will ſhew you how to find at what Hour any Star will riſe or ſet any Day of the Year; what Stars are or will be upon the North or South Meridian at any Hour given; what Stars are in the Eaſt or the Weſt, or on any Points of Azimuth at any Time of the Night; and what Altitude they have at that Hour, or at that Azimuth.

Problem XXXVI. *To find the Latitude and Longitude of any Star: Alſo its Right Aſcenſion and Declination.*

Put the Centre of the Quadrant of Altitude on the proper Pole of the Ecliptick, whether it be North or South; bring its graduated Edge to the given Star; then that Degree on the Quadrant is the *Star's Latitude*; and the Degree cut by the Quadrant on the Ecliptick is the *Star's Longitude*. Thus the Latitude of *Arcturus* is 31 Degrees North: Its Longitude is 200 Degrees from the Point *Aries*, or 20 Degrees from *Libra*. The Latitude of *Sirius* or the *Dog Star* is near 40 Degrees of South Latitude, and its Longitude is about 100 Degrees from *Aries*, or 10 Degrees from *Cancer*.

To find a *Star's Right Aſcenſion* and *Declination*, ſee Problem XVII. for it is done the ſame Way as that of the *Sun*; only obſerve this Difference, that the *Sun* changes both his Right Aſcenſion and his Declination every Day, whereas the *fixt Stars* have the ſame Right Aſcenſion and Declination all the Days in the Year.

Remember alſo, that the fixt Stars every Day in the ſame Year, keep the *ſame Longitude and Latitude*, as well as the *ſame Right Aſcenſion and Declination* *; but the Planets are ever changing all theſe, and the

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* The inſenſible Change of the Longitude, Right Aſcenſion, and Declination of the fixt Stars, made by their ſlow Motion parallel to the Ecliptick is not worth Notice in this Place.

Learner can know none of them but by ſome Almanacks which are called *Ephemerides*, or Tables which are calculated on Purpoſe to ſhew the Longitude and Latitude, or the Place of the ſeveral Planets among the twelve Signs of the *Zodiack* every Day in the Year.

Problem XXXVII. *To find the Place of any Planet on the Globe: Alſo to find at what Hour any Planet, (ſuppoſe* Jupiter*) will riſe or ſet, or will be upon the Meridian any given Day of the Year.*

You muſt firſt find out by ſome *Ephemeris*, what Degree of what Sign *Jupiter* poſſeſſes that Day of that Year: Mark that Point on the Ecliptick either with Chalk or with a Pencil, or by ſticking on a little black Patch; and then for that Day and that Night you may perform any Problem by *that Planet* in the ſame Manner as you did by a *fixed Star*.

But if you would be very exact you muſt not only ſeek the *Planet's Place* in the Sign for that Day, which is its *Longitude*, but you muſt ſeek its *Latitude* alſo in the Ephemeris (which indeed in the ſuperior Planets *Jupiter*, *Saturn*, *Mars*, alters but very little for whole Months together) and thus ſet your Mark in that Point of Latitude, or Diſtance from its ſuppoſed Place in the Ecliptick, whether Northward or Southward, and then go to work your Problem by this Mark.

I ſhall give but one Inſtance, which will ſufficiently direct to ſolve all others of the ſame Kind that relate to the Planets. On the 3d of *April* 1723; I find by an *Ephemeris* that the Sun is about the End of the 23d Degree of *Aries*, *Jupiter* enters the 8th Degree of *Capricorn*, and (if I would be very exact,) I obſerve alſo that the *Latitude of Jupiter* that Day is 15 Minutes or a Quarter of a Degree to the North: There I make a Mark or put on a ſmall black Patch on the Globe to ſtand for *Jupiter*. Then having rectified the Globe for the *Latitude* v. c. of *London*, and for the *Sun's Place*, *April* the 3d, I turn the Mark which I made for *Jupiter* to the Eaſtern Edge of the Horizon, and I find *Jupiter* will riſe near the *South-Eaſt* at a little paſt One in the Morning: He will come to the *Meridian* at a very little paſt Five: He will ſet near the *South-Weſt*, about Nine in the Morning.

Then if I rectify the Globe *for the Zenith*, the Quadrant of Altitude being brought down to the Horizon, will tell you what is his *Altitude*, and what his *Azimuth*, at any given Hour of the Morning, by the Help of the Dial and Index.

Or his *Altitude* or *Azimuth* being given you may find what it is a Clock.

By this Means you may find the Hour when the *Moon* will riſe and ſet, together with her *Southing*, or the Time of her coming to the Meridian. But let it be noted, that the Moon changes her Place in the *Zodiack* ſo ſwiftly, that ſhe moves through 13 Degrees of one Sign every Day, or thereabout; and therefore you cannot find the preciſe Hour and Minute of her *riſing*, *ſetting*, *ſouthing*, &c. upon the Globe without much more Trouble than moſt of the other Planets will give you, which change their Places in the *Zodiack* much more ſlowly.

Problem XXXVIII. *The Day and Hour of a ſolar Eclipſe being known, to find all thoſe Places in which that Eclipſe will be viſible.*

By the 13th *Problem* find out at what Place the *Sun is vertical* at that Hour of the Day. Bring that Place to the Pole or vertical Point of the Wooden Horizon, that is, *rectify the Globe for the Latitude of that Place*; then the Globe being in that Situation, obſerve what Places are in the upper Hemiſphere; for if it be a large Eclipſe the Sun will be viſibly eclipſed in moſt of them.

Problem XXXIX. *The Day and Hour of a Lunar Eclipſe being known, to find by the Globe*

*Globe all thoſe Places in which the ſame will be viſible.*

By *Problem.* XIII. find as before at what Place the *Sun is vertical at that Hour*; then by *Problem* IV. find the *Antipodes* of that Place: Rectify the Globe for the Latitude of thoſe *Antipodes*; thus they will be in the *Zenith*, or in the Pole of the Horizon; then obſerve as before what Places are in the upper Hemiſphere of the Globe, for in the moſt of thoſe Places the Moon will be viſibly eclipſed.

The Reaſon of rectifying the Globe for the *Antipodes* in this Problem, is becauſe the Moon muſt be directly oppoſite to the Sun whenſoever ſhe is eclipſed.

## SECT. XX.

### *Problems relating to* Geography *and* Aſtronomy, *to be performed by the Uſe of the* plain Scale *and* Compaſſes.

IT is ſuppoſed that the Reader is already acquainted with ſome of the firſt and eaſieſt Principles of *Geometry*, before he can read with Underſtanding this or any other Treatiſe of *Aſtronomy* or *Geography*; and it is preſumed alſo that he knows what is a *Chord*, a *Tangent* and a *Sine*, and how to make and to meaſure an Angle either by a *Line*

*Line* or *Scale of Chords*, or *Sines* or *Tangents*, in order to practiſe the Problems of this laſt Section; though a very ſlight Knowledge of theſe Things is ſufficient for this Purpoſe.

Becauſe ſeveral of the following *Problems* will depend upon the *Altitude*, or *Azimuth* of the Sun, and in order to obtain theſe, we ſometimes uſe a *Pin* or *Needle* fixed perpendicularly, on an upright or Horizontal Plane; therefore the *firſt Problem* I propoſe ſhall be this, (*viz.*)

Problem I. *How to fix a Needle perpendicular on a Plane, or to raiſe a perpendicular Style or Pointer in order to make Obſervations of a Shadow.*

*Note*, Any Thing fixed or ſet up to caſt a Shadow is called a *Style*.

One Way to perform this, is by having at Hand a *Joyner's Square*, and while one Edge of it is laid flat to the Plane, the other Edge of it ſtanding up will ſhew when a *Needle* or *Style* is fixed on that Plane perpendicularly, if it be applied to the Side of the Needle.

*Note*, If you have a little *Square* made of *Box* or any hard Wood, one Leg being ſix, or the other eight or nine Inches long, one Inch or 1 ½ broad, and an Inch thick, with a *Thread and Plummet* hanging from the End of one Leg, down toward the Place where the other Leg is joined, as in Fig. XIV. and a large Hole for the Plummet to play in: It will be of Uſe not only to ſhew you how to erect a *Needle* truly *perpendicular*; but it will alſo diſcover whether any *Plane* be truly ſmooth, and be *Horizontal* or *Level*, as well as whether any *upright Plane* be exactly perpendicular to the Horizon.

Such a *Square* will alſo be very uſeful in the Practice of any *Geometrical Problems*, by drawing one Line *perpendicular* to another with the greateſt Eaſe.

Another Way to fix a Needle perpendicular to any Plane, is this; deſcribe a Circle as *a*, *o*, *d*, *b*, in Fig. XV. Fix a Needle *s p* in the Centre *p*, then meaſure from ſeveral oppoſite Parts of it, as *a*, *o*, *d*, *b*, to the Tip of the Needle, *s*, and faſten the Needle ſo as that the Tip *s*, ſhall be at equal Diſtance from all thoſe Points, then it is truly *perpendicular*.

*Note* here, That in moſt of theſe Practices where a *perpendicular Needle* is required, the ſame End may be attained by a *Needle* or *Wire* ſtrait or crooked, which may be called a *Style*, ſet up ſloping at Random, as in Figure XVI. without the Trouble of fixing it *perpendicular*, if you do but find the Point *p* on the Plane, which lies perpendicularly under the Tip of the

Style *s*, and this may be found by applying the Edge of the Square, deſcribed Fig. xiv. to the Tip of the Style: Though there are other Ways to find this *perpendicular Point* for nice Practices in *Dialling by Shadows*, which require great Exactneſs.

But *take Notice* here, that if you uſe this Method of a *Style* ſet up ſloping at random as in Figure xvi. then with your Compaſſes you muſt meaſure the Diſtance from the Tip of the Style *s* to the Point *p*, and that Diſtance muſt be counted and uſed as the Length of the perpendicular Style *s p* in Fig. xv. whereſoever you have Occaſion to know or uſe the Length of it.

*Obſerve* alſo, that if the Tip of your Style (whether ſtrait or crooked) be more than three or four Inches high from the Plane, you will ſcarce be able to mark the Point of Shadow exactly, becauſe of the *Penumbra* or faint Shadow which leaves the Point or Edge of a Shadow undetermined.

On a Horizontal or Level Plane you muſt uſe a much *ſhorter* Style when the Sun is *low*, or in *Winter*, becauſe the Shadow is long; but in the longeſt Days in *Summer* a four Inch Style is ſufficient, though the Shadow at that Seaſon be very ſhort all the middle Hours of the Day. From the Tip of the Style to the Tip of the Shadow ſhould never be above ſix Inches diſtance.

After all, If you have frequent Occaſion for a *perpendicular Style* to obſerve a Shadow by it, I know nothing eaſier than to get a *ſmall Priſm* of Wood, or Ivory, or rather of Braſs, ſuch as is deſcribed Fig. XVII. Let the *Baſe* be a right angled Triangle A B C: The *Line* B C an Inch: A B two Inches: And let the *Height* of the Priſm, (*viz.*) A D or C E be three Inches (or near four Inches if you pleaſe.) By this means you obtain three perpendicular Styles of different Lengths, according as you want the Shadow to be either longer or ſhorter in Summer or in Winter.

If you ſet it upon the *Square Side* A B D O, your perpendicular Style will be B C or O E: If it be B O, then C is the Tip of the Style, and B marks the Point on the Plane. If you ſet it on the *Square Side* B C O E as it ſtands in the Figure, then A B, or D O is your perpendicular Style. Or if you ſet it on its *Triangular Baſe* A B C, then either A D, or B O or C E will be your perpendicular Style.

This little plain *Priſm* has theſe great Advantages in it, (*viz.*) That you can ſet it up in a Moment on a perfectly ſmooth Plane, and you are ſure it is perpendicular to the Plane; and then if you require it to ſtand there any Time, and it ſhould happen to be moved, if you have but fixed and marked its place by the lower Edges on the Plane, and remember which Edge you deſign'd for the Style, you may ſet it exactly in the ſame Poſition again.

Problem II. *How to take the Altitude of the Sun by a Needle fix'd on an Horizontal Plane, or by any perpendicular Style.*

In all theſe Practices be ſure that your Plane be truly *Level* or *Horizontal*, which you cannot well know without ſome ſuch Inſtrument as I have deſcribed before, Fig. XIV. which ſerves inſtead of a *Level.*

You muſt apply this Inſtrument or Square not only to one Part, but to every Part of the Plane, whereſoever you can imagine the Shadow will fall, to ſee if it be preciſely *Horizontal* or Level: For a very ſmall Variation from the Level will cauſe a great Difference in the Length and in the Point of Shadow; and upon this Account there are few Window-Stools, or any Boards or Poſts fix'd by the common Work of Carpenters ſufficiently Level for a Juſt Obſervation in *Aſtronomy* or *Dialling.*

Fix your perpendicular Style P S, as in Fig. XVIII. obſerve the Point of Shadow caſt from the tip of the Style S: Draw P C: Then take the Height of the Style P S in your Compaſſes; ſet it perpendicularly on P C; draw the Line S C on the Plane, and the Angle C is the *Sun's Altitude* (*viz.*) 35 Degrees.

Here it is evident that if you ſuppoſe C the Centre and C P to be the Radius, then P S is the *Tangent of the Altitude* 35 Degrees; for it meaſures the Angle C or the Arch P A. But if you make S the Centre, and ſuppoſe S P to be the Radius of a Circle, C P is the *Tangent of the Coaltitude* of the Sun, (*viz.*) 55 Degrees, for it is that Tangent which meaſures the Angle S or the Arch P E.

Hence it will follow that if you fix a *perpendicular Needle*, Pointer or Style, or any Horizontal Plane, and divide a Line, as P C, according to the Scale of Tangents, whoſe Radius ſhall be P S, beginning at P towards C, and make this Line of Tangents moveable round the Centre P, the Shadow of the Style will ſhew you the *Coaltitude of the Sun* at any time on that moveable Scale of Tangents.

Or if the Scale of Tangents P C be divided on the immoveable Horizontal Plane it ſelf, and you deſcribe concentric Circles on the Centre P thro' every Degree of that Scale, the Shadow of the tip of the Style will ſhew the *Coaltitude* among thoſe Circles; for they will exactly repreſent the Parallels of Altitude in the Heavens.

*Note*, This is deſcribed thus particularly rather for *Demonſtration* than *Uſe*, becauſe when the Sun is low the Shadow P C will be extended many Feet or Yards.

Problem III. *To take the Altitude of the Sun by a Style on a perpendicular or upright Plane.*

Fix your Style A B perpendicular to a flat Board as Fig. XIX. Raiſe your Board exactly upright, and turn it to the Sun, ſo that the Shadow of the Style A D may be caſt downward directly perpendicular from the Center A in the Line A Q. Then take the Length of the Style A B in your Compaſſes, and ſet it on the Board at right Angles to the Line of Shadow, from A to B: Draw the Line B D; and the Angle A D B ſhall be the *Sun's Coaltitude*, (or *Zenith Diſtance* as it is ſometimes called) (*viz.*) 55 Degrees: The Tangent of which is A B to the Radius D A, and the Angle A B D (which is the Complement of it) or 35$^d$. ſhall be the *Sun's Altitude*; the Tangent of which is A D to the Radius B A.

Or to make this more evident, draw the obſcure Line D O parallel to A B, *i. e.* Horizontal, and the Angle B D O will plainly appear to be the Angle of the *Sun's Altitude* 35 Degrees.

Hence it will follow, that if the Line A D be prolonged to Q, and divided according to the Degrees of a *Scale of Tangents*, this Board or Inſtrument will be always ready to ſhew the Sun's Altitude on that Scale, by the Shadow of the Style A B turn'd directly to the Sun, when the Board is held up and made to ſtand perpendicular to the Horizon.

*N. B.* This is the Foundation of thoſe Dials which are made on *Moveable Columns*, or on *Walking Canes*, which ſhew the Hour of the Day by the different Altitudes of the Sun in the various Seaſons of the Year.

*Note*, There are ſeveral other ways to find the *Altitude of the Sun* by a moveable or immoveable *upright Plane*, and a *perpendicular Style* fixed on it. But none of thoſe Ways of taking an Altitude by the Point or End of the Shadow are the moſt commodious and exact for common Uſe; I have chiefly mentioned them to lead the Learner into a more familiar and perfect Acquaintance with the Nature and Reaſon of theſe Operations.

If no regular Inſtrument be at Hand to take the *Sun's Altitude*, I perfer the following Method above any others.

Problem IV. *To find the Sun's or any Star's Altitude by a plain Board, Thread and Plummet.*

Take a ſmooth flat Board as *n o p q* which is at leaſt 8 or 9 Inches broad every

Way, *See* Fig. xx. Mark two Points on it as *a c* at leaſt at ſeven or eight Inches diſtance, and draw that Line. Fix a very ſhort Pin at *c* perpendicular which may be done ſufficiently true by gueſs. Hang a Thread and Plummet on it. Hold up the Edge of the Board to the Sun till the Shadow of the Pin be caſt all a along the Line *a c.* Obſerve where the Thread falls; mark a Point in it as at *d*; draw the Line *d c,* and the Angle *a c d* is the *Complement of the Sun's Altitude:* Or you may draw the whole Quadrant *a c e,* and then the Angle *d c e* is the *Sun's Altitude.* Now if the Arch *d e* be meaſured by a Line of Chords you find the Number of Degrees.

*Note,* That the Degrees of Altitude muſt always be reckoned from that ſide of the Quadrant which is held next to the Sun, (*viz.*) *c e.* The Coaltitude from the ſide *c a.*

*Note* farther, That the *Sun's Altitude* ſhould ſcarce ever be taken within half an Hour of Noon for any other Purpoſes beſide the finding of the *Meridian Altitude*; becauſe for an Hour together the Altitude then increaſes or decreaſes ſo very little, the Sun being then near the Middle of its diurnal Arch.

*Take Notice* alſo, That when the Sun is near the Horizon it appears higher than really it is by Reaſon of the *Refraction* or breaking of its Rays in paſſing through a larger Space of *Atmoſphere* or thicker Air. When the Sun is one Degree high its *Refraction* cauſes it to appear near half a Degree higher than it is. At two Degrees high the *Refraction* is 20 Minutes, at three Degrees the *Refraction* is 15 Minutes, at five Degrees the *Refraction* is 10 Minutes, at 10 Degrees the *Refraction* is five Minutes. You muſt therefore allow proportionably by deducting ſo much from the *apparent Altitude* when you make an Obſervation near Sun-riſe or Sun-ſet.

*Now* again, That the heavier your Plummet is, the more ſteady it will hang, and make the Obſervation more exact.

If you pleaſe you may draw the whole Quadrant on the Board, and ſtick in the Pin at the Centre before you make your Obſervation, which indeed is the moſt proper way.

You may find the *Altitude of the Moon* the ſame way. And the *Altitude of any Star* may be found by the ſame Board, if you ſtick in another very ſhort Pin perpendicular at *a*, and fixing your Eye at *s* bring both the Pins *a* and *c* juſt over the Star; then the Thread will hang (ſuppoſe) on the Point *d* in the Arch, and ſhew the Degree or Angle of Altitude to be *d c e*.

Problem V. *To obſerve the Meridian Altitude of the Sun or its Height at Noon:* And by the ſame Method *to find any Star's Meridian Altitude.*

If you know exactly when it is *Noon*, take the *Altitude of the Sun* by any Inſtrument within a Minute or two of that time, and that is the *Meridian Altitude*; for two or three Minutes at Noon make no ſenſible Difference in the Altitude.

But if you have no Clock or Dial or any thing of that kind whoſe truth you can rely on, then a little *before Noon* obſerve and ſet down the Altitude every four or five Minutes till you find it begins to grow a little leſs, then review your Obſervations, and the greateſt Height was the true *Meridian Altitude.*

You may, by the ſame Method, find the *Meridian Altitude of any Star* above the Horizon, if you make ſeveral Obſervations, when the Star is coming near to the North or South Part of the Meridian.

Problem VI. *How to find out the Declination of the Sun, or of any large or known Star.*

If you know the *Latitude of the Place* where you are, with the *Meridian Altitude of the Sun* any Day in the Year, or if you know the *Sun's Place in the Ecliptick,* you may find the *Declination of the Sun* thereby *Geometrically*, as ſhall be ſhewn afterward: But if theſe are not known, then in order to other Aſtronomical Operations, you muſt ſeek the *Declination of the Sun* for that Day, either by the *Globe* on the brazen Meridian; or in a *Scale of the Sun's Declination*, which is drawn on artificial Quadrants, or other Mathematical Inſtruments; or it may be found in *Tables of the Sun's Declination* calculated exactly to every Minute of a Degree for every Day in the Year, which is the beſt way where it may be had.

There are alſo *Tables of Declination of* ſeveral of the moſt *noted Stars*. Theſe are all the Year at the ſame Diſtance from the Equator, and their *Declination* does not vary, as the *Sun*'s does.

Theſe Tables of the Sun's and Stars Declination are found at the End of this Book, Sect. XXI.

But let it be noted here, that the *Declination of the Sun* not only changes every Day in the Year, but it differs alſo ſome few Minutes in the next Year from the Year foregoing, even on the ſame Day of the Month: Whence this Difference ariſes, and how to act with reſpect to it, ſee Problem XX. following, and more in Sect. XXI.

Problem VII. *To find the Latitude of any Place by the Meridian Altitude and Declination of the Sun any Day in the Year.*

The Way to find the *Latitude* of any Place (*i.e.* the Diſtance of the Zenith of that Place from the Equator) by the Meridian Altitude of the Sun, is firſt to ſeek its *Colatitude*, *i. e.* the Complement of its Latitude, or (which is all one) the Elevation of the Equator above the Horizon of that Place. Suppoſe the Day given be the 21ſt of June, or the Summer Solſtice.

This may be done by looking back to Figure III. Firſt, Draw the Line H O for the Horizon, and from the Centre C raiſe a Perpendicular C Z to repreſent the Zenith. Make the Semicircle H Z O for the Meridian: Then ſuppoſe the *Meridian Altitude of the Sun* at the Summer Solſtice be 62 Degrees, by the Uſe of your Compaſſes and a Scale of Chords ſet up 62 from H to S: Alſo the *Declination of the Sun* that Day being 23 ½ Degrees Northward, ſet 23 ½ from S downward, and it will find the Point E, and the Arch H E is the *Altitude of the Equator* above the Horizon, or the *Colatitude* of the Place, *(viz.)* 38 ½ Degrees: Thence you find the *Latitude* is E Z or 51 ½ Degrees which compleats a Quadrant. Then if you draw the Line E C it will repreſent the *Equator* in that Scheme.

Suppoſe you take the *Meridian Altitude of the Sun* on either of the Equinoctial Days, (*viz.*) in *March* or *September*, and you find it to be 38 ½ Degrees: Set up 31 ½ from H to E, then the Sun having no Declination the *Meridian Altitude* it ſelf ſhews you the *Height of the Equator* above the Horizon, which is the *Complement of the Latitude*.

Suppoſe the *Meridian Altitude* of the Sun at the ſhorteſt Day be 15 Degrees, ſet up 15 from H to V: Then the *Sun's Declination* is 23 ½ Degrees Southward; therefore ſet 23 ½ from V upward, and it finds the Point E: And the Arch HE is the *Complement of the Latitude* as before, (*viz.*) 38 ½ Degrees.

For all theſe Practices the chief Rule is this. In the Summer Half-Year ſet your Declination *downward* from the Point of the Meridian Altitude, and it will find the *Equator's Height* above the Horizon. In Winter ſet your Declination *upward* from the Point of the Meridian Altitude, and it will ſhew you the *Height of the Equator*. The Reaſon of it is moſt evident in the third and fourth *Figures*.

It may be proper in this Place to recollect what I have already demonſtrated in *Section* V. *Figure* IV. that the Latitude of any Place (that is the Diſtance of its Zenith from the Equator) Z E is equal to the Elevation of the Pole P O above the Horizon. Thereby it appears that the *Elevation of the Equator* above the Horizon of that Place on one Side as E H (which is the Complement of the Latitude) is equal to the Complement of the *Pole's Elevation* on the other ſide as Z P. If therefore the *Latitude* (ſuppoſe of *London*) be E Z or P O 51½ the *Colatitude* P Z or H E will be 38½ for it muſt compleat a Quadrant or 90 Degrees; and therefore if you ſet the Point P 51½ Degrees above O on the other ſide of the Horizon, and draw the Line P C, you have the *Axis of the World* repreſented, or the *North Pole* in its proper Elevation for *London*, and ſtanding (as it ought) at right Angles with the Equator E C.

I have repreſented the Solution of this ſixth Problem in a *Geometrical manner* to ſhew the Reaſon of this Practice; but this Problem of *finding the Latitude by the Meridian Altitude* is much eaſier performed *Arithmetically* thus.

In the Winter Half-Year add the *Declination* to the *Meridian Altitude*, and it gives you the *Colatitude*.

In the Summer Half-Year ſubſtract the *Sun's Declination* from the *Meridian Altitude*, and it gives the *Colatitude*.

Example *June* 11th

*Merid. Alt.* HS——62
*Sun's Declin.* ES——23 ½ Subſtract

*Colatitude* HE——38 ¼

*December* 11th

*Merid. Alt.* HV——15
*Sun's Declin.* EV——23 ½ Add

*Colatitude* HE——38 ½

Then if you ſubſtract the Colatitude from the *Zenith* or 90, you find the Latitude, as,

*Zenith* HZ——90
*Colatitude* HE——38 ½ Subſtract

*Latitude* EZ——51 ½

After all it muſt be obſerved here, that all theſe Problems of finding the Latitude of the Place by the Sun's or Star's Meridian Altitude, *&c.* belong chiefly to thoſe Places which lie within the *Temperate Zones.* If the Place lie in the *Torrid* or *Frigid Zones*, theſe Methods of Solution are good, when the Meridian Sun is on the ſame Side of the *Zenith* with the *Equator*, whether North or South. But if not, then there muſt be ſome little Difference of Opperation at ſome times of the Year. Yet if you project a Scheme for the Solution of ſuch an Enquiry like Fig. III. the very Reaſon of things will ſhew you when you muſt Add or Subſtract.

Problem VIII. *To find the Meridian Altitude of the Sun any Day of the Year, the Latitude of the Place being given.*

This is but the Converſe of the former Problem, and therefore is to be performed the contrary Way, (*viz.*) in Winter ſubſtract the *Declination* V E from the *Equinoctial Altitude* or *Colatitude* H E, and the Remainder is H V the *Meridian Altitude.*

In Summer add the *Declination* E S to the *Equinoctial Altitude*, or *Colatitude* H E, and it gives the *Meridian Altitude* H S.

The *Meridian Altitude* at the Equinoxes is the ſame with the *Colatitude* as before.

Problem IX. *To find the Declination of the Sun, its Meridian Altitude and the Latitude of the Place being given.*

It is hardly neceſſary to deſcribe this Practice to thoſe who have perfectly learn'd the two foregoing *Problems.*

*Subſtract* the Colatitude H E from the Meridian Altitude in *Summer* H S, and the Remainder is the *Sun's Summer Declination* E S.

*Subſtract* the Meridian Altitude in *Winter* H V from the Colatitude H E, and the Remainder is the *Sun's Winter Declination* E V.

Or in ſhort, if the Meridian Altitude and Colatitude be given, *ſubſtract the leſs from the greater*, and the Remainder is the *Sun's Declination.*

Problem X. *To find the Latitude of a Place by the Meridian Altitude of a Star, when it is on the South Meridian.*

Find the Declination of that Star in ſome Table or Scale of the Star's Declination. If it has *Declination Northward*, (as the Sun has in Summer) ſubſtract the Declination from the Meridian Altitude, and it gives you the *Colatitude.*

If the Star's *Declination* be *Southward* (as the Sun's is in Winter) add its Declination to its Meridian Altitude, and it gives you the *Colatitude.*

*Note*, When I ſpeak of North and Southward in relation to Winter and Summer, in many of theſe Problems, I mean in *Northern Latitude* ſuch as ours is in *Britain.*

When the Star is on the *North Meridian* ſee how to find the Latitude by it in *Problem* XXXII.

Problem XI. *By what Methods is the Longitude of Places to be found.*

Though the *Latitude* (which lies *Northward* and *Southward*) may be determined with the utmoſt Certainty by the Methods before propoſed, yet the *Longitude* of a Place (which is the *Diſtance of any two Places* from each other *Eaſtward* or *Weſtward*) is very hard to be determined by the Sun or Stars, becauſe they always appear moving round from *Eaſt to Weſt*. The *Longitude* therefore of Places is uſually found by meaſuring the Diſtance on Earth or Sea from *Weſt* or *Eaſt*.

The *Map-Makers* who deſcribe Countries, Provinces or Kingdoms, meaſure the Diſtances on the Earth by an Inſtrument made on Purpoſe, with a *Wheel* ſo contrived, that a certain Number of its Revolutions is equal to a Pole, a Furlong, or a Mile; it hath alſo a *Mariner's Compaſs* and Needle touch'd with a Loadſtone faſtned to it, to ſhew how much their courſe varies from the *North* or *South*.

In this laſt Age they have alſo invented a Way to find the *Difference of Longitude* between two Towns that are ſome thouſands of Miles aſunder in diſtant Nations; and that is by a nice and exact Obſervation of the Moment when the *Eclipſes of the Moon* begin or end, made by Mathematicians at thoſe diſtant Places: And thus by the Difference of Time in thoſe Eclipſes they compute the Diſtance of Place.

This Invention is ſtill further improved by Obſervations of the *Eclipſes of the four Moons* or little ſecondary Planets, which roll round the Planet *Jupiter* as our Moon does round our Earth: By theſe Means the ſuppoſed Diſtances of ſome Places in the *Eaſt* and *Weſt-Indies* have been altered, and the Miſtakes of ſeveral hundred Miles corrected.

The *Sailors* meaſure it at Sea by the *Log*, which is a piece of Board faſtened to a long Line which they caſt out of the Ship while a Minute or Half-Minute Glaſs begins to run: Then drawing in the *Log*, they ſee how far the Ship has ſailed *in a Minute*; and ſuppoſing the Circumſtances of the Wind and Water to be the ſame, they compute thereby how far they have ſail'd in *ſome Hours.* But this being a very uncertain Way of reckoning becauſe of the continual Changes either of the Strength or the Point of the Wind, or current of the Water, they are often liable to Miſtakes. Therefore it has been the famous and ſolicitous Enquiry of theſe laſt Ages how to find out and aſcertain *Longitude* at Sea; and there is ſo vaſt a Reward as twenty thouſand Pounds offered by the Parliament of *Great-Britain* to any Man who ſhall invent a Method for it, which ſhall be plain, eaſy and practicable at Sea.

Problem XII. *To find the Value of the Degree of a greater Circle upon the Earth, or how much it contains in* Engliſh *Meaſure.*

Here let it be noted, that one Degree of a greater Circle on the *Earth* anſwers to one Degree of a greater Circle in the *Heavens.* It is true the heavenly Circles are incomparably larger than the Circumference of the Earth; and they are alſo larger than each other according to the different Diſtances of the Planets and Stars; yet every Circle (whether greater or leſſer) is divided into 360 Degrees, and therefore though Circles differ never ſo much in Magnitude, yet, when they are ſuppoſed to be *concentrical*, (*i. e.* to have the ſame Centre) every ſingle Degree of each Circle is correſpondent to a ſingle Degree of all other Circles.

Now that a Degree of the *Heavens* thus anſwers to a Degree on the *Earth* is very evident; for if we travel on *Earth*, or ſail one Degree *Northward* or *Southward* on the ſame *Meridian*, we ſhall find by the Sun or the fixed Sars in *Heaven* that our Zenith is juſt a Degree altered, our Latitude is changed one Degree, and our *Pole* is one Degree more or leſs elevated, (*viz.*) more elevated if we go from *London* toward the *North*, and leſs elevated if we go toward the *South*, till we come to the *Equator:* Afterward the contrary Pole is elevated gradually. By ſuch Experiments as theſe Philoſophers infer alſo that the *Earth is a Globe* and not a plane Surface.

Wherefore *to find the Value of a Degree on a greater Circle of the Earth*, you muſt travel directly in the *ſame Meridian*, meaſuring your Miles all the Way, till your *Latitude* be alter'd one Degree; and then (if you have been exact in your Meaſure) you will find that you have travelled about 70 *Engliſh Miles*; though Geographers often reckon 60 *Geographical Miles* to a Degree for greater Eaſe in Computation, as I have ſaid before.

Problem XIII. *To find the Circumference, the Diameter, the Surface and ſolid Contents of the Earth.*

Having found the Value of one Degree to be 70 *Miles*, multiply that by 360, and it produces 25200 Miles for the *Circumference*.

The *Diameter* is in proportion to the *Circumference* as 113 to 355, or as 50 to 157, or in more brief and vulgar Account as 7 is to 22, which will make the *Diameter* of the Earth to be about 8000 Miles.

Multiply the Curcumference by the Diameter, and that Product ſhall be the *Square Feet*, *Furlongs*, *Miles*, &c. of *the Surface*.

Multiply the Surface by the ſixth part of the Diameter, and that will give the *ſolid Content*.

*Note*, That Geographers differ a little in the Computation of theſe Meaſures, becauſe they differ in the Meaſure of a ſingle Degree: And that is becauſe of the Crookedneſs and Inequality of any Road that you can travel for 70 Miles together: The juſteſt Meaſures have made 69 ½ Miles go to a Degree, or the round Number of 70 Miles.

Problem XIV. *To find the Value of a Degree of a leſſer Circle on the Earth*, i. e. *the* Value of a *Degree of Longitude* on the *leſſer Parallels of Latitude.*

I have mentioned it before under the III^d *Prob.* of the 19^th *Sect.* that all the Degrees marked on the Equator, or on any of the Meridians are 70 Miles, becauſe all thoſe Lines are *Great Circles*; yet in the *Parallels of Latitude*, the further you go from the Equator, the *Circle* grows leſs and leſs, and conſequently each *Degree* of it muſt be leſs alſo; and for this Reaſon the whole Circle of 360 *Degrees* near the Pole will not make above 360 *Miles*; and as you approach ſtill nearer to the Pole, it will not make ſo many *Furlongs* or *Feet.*

To find therefore the *true Value of a Degree* ſuppoſe in the *Parallel of Latitude of London* 51 ½ Degrees, uſe this Method, Fig. XXII. Make a ſtraight Line A B to repreſent one Degree in the Equator, divide it into 60 *Geographical Miles*, or into 70 *Engliſh Miles*, all equal: Set the Foot of your

Compaſſes in A, deſcribe an Arch from B to C of 51½ Degrees, then from the Point C let fall a Perpendicular to D, and A D is the Meaſure of a *Degree of Longitude in the Parallel of London*, (*viz.*) about 43½ Miles.

The Demonſtration of it may thus be explained. Prolong the Arch B C and complete the Quadrant E A B. Then E ſhall repreſent the North Pole: E A the Northern Half of the Axis of the World, A B the Semidiameter at the Equator, and N C the Semidiameter of the Parallel of Latitude for *London*. Then *Arithmetically*, if the Line A B (ſuppoſe 1000 equal Parts) allow 70 Miles for a Degree, what will N C (*i.e.* about 621 equal Parts) allow? *Anſ.* 43½

Or *Trigonometrically* thus. A B is the whole Sine of $90^d$, or Radius. N C is the Sine of the Colatitude $38^d$½. Then ſay, As A B or the Sine $90^d$ is to 70 Miles, ſo is N C or A D the Sine of $38^d$½ to 43½ Miles.

*Note*, this Diagram or Figure will ſhew the value of a Degree of Longitude in any Parallel of Latitude, if from every Degree in the Arch E C B a Perpendicular were drawn to the Line A B.

Therefore a whole Line of Sines if number'd backward, and applied to a Scale of 70 equal Parts, will ſhew the Miles contain'd in one Degree of Longitude under any Parallel of Latitude whatſoever.

Having ſhewn in former Problems how to take the *Meridian Altitude of the Sun*, and thereby to find the *Latitude of any Place* on the Earth, I think it may be proper now to ſhew how to *project the Sphere* for any Latitude upon the Plane of the Meridian, and repreſent it in ſtraight Lines, which is called the *Analemma:* Becauſe the Erection of this Scheme (and ſometimes of a little Part of it) will ſolve a variety of *Aſtronomical* Problems, as will appear hereafter.

Problem XV. *To erect the* Analemma, or *repreſent the Sphere in ſtraight Lines for the Latitude of London* 51 ½ *Degrees.*

*Firſt*, It is ſuppoſed you have a *Scale of Chords* at hand, or a *Quadrant* ready divided into 90 Degrees. Take the Extent of 60 Degrees of the Line of Chords in your Compaſſes, (or which is all one) the Radius of your Quadrant, and deſcribe the Circle N Z E H S Q for a Meridian both North and South as in *Figure* XXIII. (*viz.*) N E S, which repreſents 12 o'clock at Noon; and N Q S, which repreſents the Hour of Midnight.

Through C the Centre draw the Line H O for the *Horizon.* At 90 Degrees diſtance from H and O mark the Point Z and D for the *Zenith* and *Nadir*; then draw the Line Z D which will croſs H O at Right

Angles,

Angles, and will repreſent the *Azimuth of Eaſt and Weſt*; as the Semicircle Z O D repreſents the *North Azimuth*, and Z H D the *South*.

Above the *Horizon* O mark N for the *North Pole* elevated 51½ Degrees: Through the Centre C draw the Line N S for the *Axis of the World*; which Line will alſo repreſent the *Hour Circle of ſix o'clock*, being at 90 Degrees diſtance from *Noon* and *Midnight*. S will ſtand for the *South Pole*, depreſs'd as much below H the South ſide of the Horizon, as N the *North Pole* is raiſed above O on the North ſide of it.

At 90 Degrees from N mark E and Q on each ſide; then croſs the *Axis of the World* N S with the Line E Q at right Angles, which repreſents the Equator. Thus E will be 90 Degrees from N the *North Pole*, 51½ Degrees from Z the Zenith, which is the Latitude, and it will be 38½ Degrees above H the *Horizon* which is the Complement of the Latitude.

At 23½ Degrees from E on each ſide mark the Points M and W; then parallel to the *Equator* or E Q draw the Line M ♋ for the *Tropick of Cancer*, and the W ♑ for the *Tropick of Capricorn*. After that, through the Centre C draw M ♑ which is the *Ecliptick*: It cuts the Equator E Q in C, and makes an Angle with it of 23½ Degrees.

From the Points N S mark *p* and *x* on each ſide at the Diſtance of 23 ½ Degrees, *p p* are the *Poles of the Ecliptick,* and the Line *p x* and *x p* being drawn are the two *Polar Circles, (viz.)* the *Artic* and *Antartic.*

Thus *Analemma* is compleated for all general Purpoſes or Problems.

The further Obſervables in it are theſe, *viz.*

M is the *Sun's Place* in the Ecliptick when it enters *Cancer* at the Summer Solſtice: And the Arch E M is its *North Declination* 23 ½ Degrees.

C is the *Sun's Place* in the Ecliptick entering *Aries* or *Libra* at the Equinoxes: And then it has no *Declination.*

♑ is the *Sun's Place* in the Ecliptick entering *Capricorn* at the Winter Solſtice: And the Arch ♑ Q or (which is all one) E W is its *South Declination* 23 ½ Degrees.

The Line M ♋ is the *Sun's Path* the *Longeſt Day,* or at the *Summer Solſtice*; it is at ♋ at Midnight; it riſes at R; it is at ſix o'clock at 6; it is in the Eaſt Azimuth at V; it is on the Meridian at M that Day, and the Arch M H is its Meridian Altitude, (*viz.*) 62 Degrees.

The Line E Q is the *Sun's Path* on the *two Equinoctial Days* at *Aries* and *Libra*; it is at Midnight at Q; it riſes at C, and it is in the ſame Moment at the Eaſt, and ſix o'clock; for on the Equinoctial Days

Z D the Azimuth of Eaſt and Weſt, and N S the ſix o'clock Hour Line both meet at C in the Horizon H O, which never happens any other Day in the Year: Then the Sun goes up to E at Noon; and E H is the Arch of its Meridian Altitude at the Equinoxes, (*viz.*) 38½ Degrees.

W ♑ is the *Sun's Path* the *Shorteſt Day*, or at the *Winter Solſtice*; it is Midnight at ♑; it is in the Eaſt at K long before it riſes; it is ſix o'clock at G before it riſes alſo; then at I it riſes or gets above the Horizon; it is Noon at W, and its Meridian Altitude is W H or 15 Degrees.

The Sun's *Aſcenſional Difference* (that is, its Diſtance from ſix o'clock at its Riſing or Setting) in the *Summer* Solſtice is the Line R 6, and at the *Winter* Solſtice 'tis the Line I G.

Its *Amplitude* (or Diſtance from Eaſt or Weſt at its Riſing or Setting) in *Summer* is R C; in *Winter* 'tis I C.

Here you muſt ſuppoſe that the Sun goes down again from the Meridian in the Afternoon on t'other ſide of the Scheme or Globe in the ſame manner in which its Aſcent toward the Meridian is repreſented on this Side: So that the Line M R repreſents the Sun's *Semidiurnal Arch at Midſummer*, E C at the *Equinoxes*, and W I at *Mid-winter*. The *Semidiurnal Arch* is half the Arch it makes above the Horizon.

*Note*, That as we have deſcribed the various Places of the Sun's Appearance *above the Horizon* H O at the ſeveral Seaſons of the Year, ſo the various Places of its Depreſſion *below the Horizon* H O may be eaſily found out and deſcribed by any Learner.

Problem XVI. *How to repreſent any Parallel of Declination on the Analemma, or to deſcribe the Path of the Sun any Day in the Year.*

Find out what is the *Sun's Declination* that Day by ſome Scale or Table: Obſerve whether it be the *Winter* or the *Summer* Half-year; and conſequently whether the Declination be *North* or *South:* Then for the North ſide of the Equator, if it be Summer, ſet the Degrees of *North Declination* upward from E toward Z; if it be Winter ſet the *South Declination* downward from E toward H: And from the Point of Declination (ſuppoſe it be M or W) draw a Line parallel to E Q the Equator, as M ♋ or W ♑, and it repreſents the *Parallel of Declination*, or the *Path of the Sun* for that Day.

Problem XVII. *How to repreſent any Parallel of Altitude, either of the Sun or Star on the Analemma.*

As the Lines of *Declination* are parallel to the *Equator*; ſo the Lines of *Altitude* are parallel to the *Horizon:* Suppoſe therefore the Altitude of the Sun be about 42 Degrees; ſet up 42 Degrees on the Meridian from H to A, draw the Line A L parallel to H O, and it deſcribes the *Sun's Parallel of Altitude* that Moment.

Here *Note*, that where the Sun's *Parallel of Declination* for any Day and his *Parallel of Altitude* for any Moment croſs each other, that is an exact Repreſentation of the *Sun's Place in the Heavens* at that Time: Thus the Point *Sol* ☉ is the preciſe Place where the Sun is when he is 42 Degrees high on the longeſt Day of the Year: for M ♋ repreſents his *Path or Parallel of Declination* that Day, and A L repreſents his *Parallel of Altitude* that Moment.

I might add here alſo, that the prick'd Arch N ☉ S repreſents the *Hour Circle* in which the Sun is at that Moment; and Z ☉ D repreſents its *Azimuth* or *vertical Circle* at that Time. *Note*, Theſe Arches are troubleſome to draw aright, and are not at all neceſſary to ſolve common Problems by the Scale and Compaſſes on the Analemma.

### Problem XVIII. *The Day of the Month and the Sun's Altitude being given, how to find the Hour or Azimuth of the Sun by the Analemma.*

The two foregoing Problems acquaint you how to fix the preciſe *Point* of the *Sun's Place* any Minute of any Day in the Year by the *Parallel of Declination* and *Parallel of Altitude* croſſing each other.

Now ſuppoſe the Day of the Month be the 6th of *May*, and the *Sun's Altitude* 34 Degrees in the Morning. Deſcribe the Semicircle H Z O in Figure XXIV. for the Meridian. Make H C O the Horizon. Draw E C making with H C an Angle of the Colatitude 38 ½ Degrees to repreſent the Equator. Seek the *Declination of the Sun*, and in the Tables or Scales you will find it near 16 ½ Degrees Northward: Set 16 ½ from E to D; draw D R for the Path of the Sun that Day, parallel to E C the Equator. Then ſet the Altitude $34^{d}$. from H to A. draw A L parallel to H O the Horizon, Thus the Point ☉ ſhews the Place of the Sun as before.

Now if you would find the *Hour*, you muſt draw the Line C N at right Angles with the Equator E C, which repreſents the ſix a Clock Hour Line; and the Diſtance 6 ☉ is the *Sun's Hour from ſix*; that is, his Hour after ſix in the Morning, or before ſix in the Afternoon.

If you are to ſeek the *Azimuth*, then you muſt draw the Line C Z perpendicular to H O, which is the vertical Circle of Eaſt or

Weſt; then the Extent F O is the *Sun's Azimuth from Eaſt*, in the Morning, or *from Weſt* in the Afternoon.

Thus you ſee that in order to ſolve thoſe two difficult Problems of the *Hour* or *Azimuth*, you need but a very few Lines to perform the whole Operation; for if you want only the *Hour*, C Z may be omitted; if you want only the *Azimuth*, C N may be omitted.

Yet in the Winter Half-year, ſuppoſe the 13th of *November*, when the *Declination* is near 18 Degrees South, it muſt be ſet downward as E W from E toward H; then you cannot ſo well find the Hour without producing the ſix a Clock Line N C below the Horizon down to S, that you may meaſure the Hour from S or ſix.

Obſerve alſo that this little Diagram in Figure XXIV. will ſolve a great Variety of Problems beſides the *Hour* and *Azimuth* on the 6th of *May*: It ſhews the *Length of the Day* by the Semidiurnal Arch D R. The *Sun's Aſcenſional Difference* is 6 R. His *Amplitude* is C R. His *Azimuth* from Eaſt or Weſt at ſix is T 6. His *Altitude* at *Eaſt* and *Weſt* is V C. His *Meridian Altitude* is the Arch D H: And his *Azimuth* from Eaſt or Weſt *at riſing or ſetting* is the Line C R.

Problem XIX. *How to meaſure the Number of Degrees on any of the ſtraight Lines in the Analemma.*

I think there is no need to inform the Reader that any Part of the outward Circle or *Meridian* may be meaſured upon that Scale of Chords or Quadrant, according to whoſe Radius the whole *Analemma* is drawn.

As for the *ſtraight Lines* they are all to be conſidered as *Sines*; thoſe Semidiameters which are drawn from the Centre c to the Curcumference are ſo many *whole Lines of Sines* or 90 Degrees to the common Radius of the Semicircle. But if you conſider any *whole Diameter* which paſſeth through the Centre c, it is a Line of *verſed Sines*, i. e. two Lines of right Sines joined at their Beginning to the ſame common Radius of the Semicircle.

If therefore you have a *Scale* or *Line of Sines* at hand to the ſame Radius of the Circle, you may meaſure any Part of thoſe ſtraight Lines, ſetting one Foot of the Compaſſes in the Centre c, and extending the other to the Point propoſed, then applying that Extent to the beginning of the Line of Sines, and obſerving how far it reaches.

But if you have no *Scale* or *Line of Sines* at hand, you may find a Quantity of any Part of the Semidiameter by the outward Limb or Semicircle, and by the Scale of Chords, according to whoſe Radius the Semicircle is drawn. The Method of performing it ſee in Figure xxv, where the

Quadrant *y x b* is drawn by the ſame Radius as the Semicircle in Figure XXIV. But I choſe to make it a diſtinct Figure, leſt the Lines ſhould interfere with one another and breed Confuſion; and therefore in Figure XXIV. I have uſed capital Letters, in Figure XXV. all the Letters are ſmall.

Suppoſe I would find how many Degrees are contained in v c which is the *Sun's Altitude at Eaſt or Weſt.* This is a Part of the Semidiameter, c z: Suppoſe therefore c z to be a whole Line of Sines, beginning to be number'd at c. Take the Extent v c in your Compaſſes, and carry one Leg up in the Arch *y x* till the other Leg will but juſt touch the Diameter *y b*, and the Leg of the Compaſſes will reſt at *n*; wherefore it appears that c v in Fig. XXIV. is the Sine of the Arch *y n* in Figure XXV. or 21 Degrees.

Another Way to perform it is this. Take the Extent v c, ſet one Leg of the Compaſſes in *y*, and with that Extent make a blind or obſcure Arch at *e*, and by the Edge of that Arch lay a Rule from the Centre *b*, and it will find the Point *n* in the Limb (*viz.*) 21 Degrees.

By the ſame Practice you may find the Number of Degrees contained in any Part of thoſe Lines which are drawn from the

Centre C, (*viz.*) C H, C E, C M, C Z, C N, C O, all which are whole Lines of Sines to the common Radius of the Quadrant.

But as for thoſe *Lines* in the *Analemma* which are not drawn from the Centre C, but are drawn acroſs ſome other Diameter and produced to the Limb, ſuch as the Line 6 D, the Line S W, the Line F A, and the Line F L, each of theſe are to be eſteemed as a *whole Line of Sines* alſo, but to a *leſs Radius.*

So 6 ☉ Figure XXIV. in the *Sine of the Sun's Hour from* 6; but the Radius is 6 D, and the Number of Degrees in 6 ☉ is to be found in this manner. Take the Extent 6 D, or this whole leſſer Radius in your Compaſſes, and ſet it from *b* to *q* in Figure XXV. then take the Extent 6 ☉, and ſetting one Foot of the Compaſſes in *q*, make an obſcure Arch at *o*, and a Ruler laid from *b* the Centre by the Edge of that Arch *o* will find the Point *d* in the Limb, and ſhew that *d y* is 34 ¼ Degrees, which (turned into Hours) is *two Hours* 17 *Minutes* from ſix, (*viz.*) 17 Minutes paſt eight in the Morning, to 43 Minutes paſt three in the Afternoon.

Again F ☉ in Figure XXIV. is the *Sine of the Azimuth from Eaſt to Weſt* to the Radius F A; take therefore F A in your

Compaſſes and ſet it from *b* to *p* in Figure XXV. then take the Extent F ⊙ and with one Foot in *p* make the obſcure Arch *a*; by the Edge of that Arch lay a Ruler from *b* the Centre, and you will find the Point *s* in the Limb; therefore *y s* is the *Azimuth from Eaſt to Weſt*, that is, about 17 Degrees.

*Note*, If you have the Inſtrument called a *Sector* at hand and know how to uſe it, you may with great Eaſe and Exactneſs find the value of any Sine in the *Analemma*, whether it be to a greater or a leſſer Radius, without theſe Geometrical Operations.

Problem XX. *To find the Sun's Place in the Ecliptick any Day in the Year.*

It is well known that the 12 Signs of the *Zodiack*, each of which has 30 Degrees, conain in all 360 Degrees: And the Sun is ſaid to go thro' them all once in twelve Months or a Year. Therefore in a vulgar Account, and for the Uſe of Learners, we generally ſay, the Sun goes through one Degree in a little more than a Day, and thereby finiſhes the 360 Degrees in 365 Days. But this is not the juſteſt and moſt accurate Account of Things: Let us therefore now toward the End of this Book, with a little more Exactneſs obſerve,

1. That the annual Courſe which the *Sun* appears to take through the *Ecliptick* round the Earth, is much more properly and truly aſcribed to the *Earth*'s moving or taking its Courſe round the *Sun*; tho' the common Appearances to our Eye are much the ſame as if the *Sun* moved.

2. This annual Courſe or Path of the Earth is not properly a *Circle*, but an *Ellipſis* or oval: And as the *Sun* is fixed in one of the *Focus*'s of the *Ellipſis*, ſo the fixed Stars, (and among them the 12 Signs) ſurround and encompaſs it. See Fig. XXXI. where the black Point *t* is the *Earth* in its Orbit moving round, and ⊙ the *Sun* near the Middle, and the outward Circle of Points is the *ſtarry Heaven*.

3. That Part of this Ellipſis or Oval, which the Earth traces in our *Winter* Half-year, (*i. e.* from Autumn to Spring) is nearer to the Sun than the other Part of it which the Earth traces in our *Summer* Half-year, (*i. e.* from Spring to Autumn.) And as it is nearer to the Sun, ſo conſequently it is the ſhorter or leſſer half, if I may ſo expreſs it. The very Figure ſhews it plainly.

*Note*, By *our Winter* and *our Summer* I mean thoſe Seaſons as they reſpect us in *Europe*, and in theſe *Northern* Parts of the Globe.

4. Thence it follows that the Sun appears to finiſh its Winter Half-year from *September* 23d to *March* 20th, *i.e.* from ♎ by ♑ to ♈ ſooner by 7 or 8 Days than it does the Summer Half-year, *i. e.* from ♈ by ♋ to ♎, or from *March* 20th to *September* 23d, which is proved thus: When the Earth is at *t*, the Sun appears at ♋ and it is *Midſummer*. When the Earth is at *e* the Sun appears at ♎ and it is *Autumn.* When the Earth is at *o* the Sun appears at ♑ and it is *Midwinter*. And when the Earth is at *a* the Sun appears at ♈ and it is *Spring*. Thus the Sun appears to paſs through thoſe Signs which are juſt oppoſite to thoſe which the Earth paſſes. Now as the Earth is longer in going through the Arch *a t e*, from ♎ to ♈, than it is in going through the Arch *e o a*, from ♈ to ♎, ſo conſequently the Sun appears to paſs through the oppoſite Signs from *Aries* to *Libra*, ſlower than he does from *Libra* to *Aries*.

This is proved alſo plainly by the Computation of Days.

After the Sun enters *Aries* on *March* 20th, that Month hath 11 Days, and after the Sun enters *Libra* on *September* 23d, that Month hath 8 Days. Now let us compute.

*March*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *March* | 11 | | ♈ | *September* | 8 | | ♎ |
| *April* | 30 | | | *October* | 31 | | |
| *May* | 31 | | | *November* | 30 | | |
| *June* | 30 | Days | | *December* | 31 | Days | |
| *July* | 31 | | | *January* | 31 | | |
| *Auguſt* | 31 | | | *February* | 28 | | |
| *September* | 22 | | ♎ | *March* | 20 | | ♈ |
| *Summer* | 186 Days | | | *Winter* | 179 Days | | |

5. Agreeably hereto it is found that in the Winter Months (chiefly from the latter end of *October* to the middle of *March*) the Sun appears to move ſomething more than one Degree in a Day: But in the Summer Months (chiefly from the middle of *March* to the latter end of *October*) the Sun appears to move ſomething leſs than one Degree in a Day. This is one Reaſon why a good Pendulum Clock meaſures Time more juſtly than the Sun: And it is this Irregularity of the Sun's meaſuring Time that makes the Tables of Equation of Time neceſſary.

6. And thence ariſes a ſenſible Inequality between the Times of the Sun's apparent Continuance in different Signs of the *Zodiack*: He ſeems to tarry longer in thoſe of the Summer, and ſhorter in thoſe of the Winter: So that he does not leave one Sign, and enter another juſt in the ſame Proportions or Diſtances of Time every Month.

7. This occaſions a little Variation of the *Declination* of the Sun, and his *Right Aſcenſion* from the Regularity that we might expect; for they are both derived from his apparent Place in the *Ecliptick:* And therefore none of them can be found by Learners with utmoſt Exactneſs, but in an *Ephemeris* or Tables which ſhew the *Sun's Place*, &c. every Day in the Year.

8. Let it be noted alſo, that the *Leap-year* with its additional Day the 29th of *February*, returning every four Years, forbids the Sun's Place in the *Ecliptick* to be exactly the ſame at the ſame Day and Hour of the following Year, as it was in the foregoing; ſo that though you knew the *Sun's Place*, his *Right Aſcenſion* and *Declination* for one whole Year, that would not ſerve exactly for the next Year, for the niceſt Purpoſes of Aſtronomy.

9. Yet as in four Years Time the Sun appears very nearly at the ſame Place in the Heavens again at the ſame Day and Hour and Minute as before, ſo a Table that contains the Round of four Years is a ſufficient Direction for 20 Years to find the *Sun's Place* for any common Purpoſes :- Provided always that we ſeek the *Sun's Place*, *Declination or Right Aſcenſion*, for any Year and Day in that Year in the Table that is equally diſtant from Leap-year, whether it happens to be the

firſt, the ſecond, or the third after Leap-year, or whether it be the Leap-year, it ſelf. See more of this Matter *Sect.* XXI. of the *Tables of Declination.*

10. If we would make one ſingle Table or Scale of the Sun's *Entrance* into the Signs of the *Zodiack*, or of his *Declination* or *Right Aſcenſion* to ſerve for every Year, we muſt chuſe the ſecond after the Leap-year, becauſe that comes neareſt to the *mean* or *middle Courſe and Place of* the Sun, and will occaſion the leaſt Error in any Opperations.

I have therefore here ſet down a ſhort *Table* of the Sun's Entrance into the ſeveral Signs, for the Year 1754, which is the ſecond after Leap-year; and for Geometrical Operations with a plain Scale and Compaſs, it is ſufficiently exact for 20 Years to come.

*Anno* 1754, the ſecond after Leap-year.

| | Day | | d. m. | | Day | | d. m. |
|---|---|---|---|---|---|---|---|
| *March* | 20 | ♈ | 0 : 09 | *Sept.* | 23 | ♎ | 0 : 21 |
| *April* | 20 | ♉ | 0 : 19 | *Oct.* | 23 | ♏ | 0 : 3 |
| *May* | 21 | ♊ | 0 : 16 | *Nov.* | 22 | ♐ | 0 : 14 |
| *June* | 22 | ♋ | 0 : 51 | *Dec.* | 22 | ♑ | 0 : 44 |
| *July* | 23 | ♌ | 0 : 25 | *Jan.* | 21 | ♒ | 0 : 33 |
| *Auguſt* | 23 | ♍ | 0 : 11 | *Feb.* | 20 | ♓ | 0 : 55 |

It is not poſſible to form all this irregular Variety of Times when the Sun enters the ſeveral Signs into any Memorial Lines or

Rhymes with any Exactneſs and Perſpicuity; and therefore I have omitted the Attempt. Such a ſhort *Table* as this may be always carry'd about by any Perſon who deals frequently in ſuch Opperations and Inquiries.

But to give an Example of the Practice. Suppoſe it be inquired, what is the Sun's Place, *April* 25th, I find the Sun juſt entered into *Taurus* ♉ *April* the 20th, then I reckon it is in the 5th Degree of ♉ *April* 25th, which added to the whole 30 Degrees of *Aries*, ſhews the Sun to be 35 Degrees from the Equinoctial Point ♈ on the 25th of *April*.

If the 29th of *November* we enquire the Sun's Place, we muſt conſider the Sun is juſt entered ♐ the 22d of *November*: Therefore on the 29th it is about 7 Degrees in ♐, which added to 30 Degrees of ♏ and 30 Degrees of ♎, ſhews the Sun on the 29th of *November*, to be about 67 Degrees from the Autumnal Equinox or ♎.

Thus by adding or ſubſtracting as the Caſe requires, you may find the *Sun's Place* any Day in the Year: And thence you may compute its Diſtance from the *neareſt Equinoctial Point*, which is of chief Uſe in Operations by the *Analemma*.

Problem XXI. *The Day of the Month being given, to draw the Parallel of Declination for* *that Day without any Tables or Scales of the Sun's Declination.*

This may be done two Ways. The *firſt* Way is by conſidering the *Sun's Place in the Ecliptick*, as *May* the 6th, it is 46 ½ Degrees from the Equinox Northward. Therefore in *Figure* XXIV. after you have drawn H Z O the Meridian, E C the Equator, ſet up 23 ½ Degrees the Sun's greateſt Declination from E to M; draw M C to repreſent the *Ecliptick*; then take 46 ½ Degrees from a Line or Scale of Sines and ſet it from C the Equinoctial Point to K in the Ecliptick; through the Point K, draw D R parallel to E C the Equator. Thus D R repreſents the *Sun's Path* that Day, and ſhews the *Declination* to be E D or 16 ½.

*Note*, If you have ne'er a *Scale of Sines* at hand, then take the *Chord* or the *Arch* of 46 ½ Degrees, ſet it up in the Limb from H to G, ſet one Foot of the Compaſſes in G, and take the neareſt Diſtance to the Line H O or Diameter, and that Extent is the *Sine* of 46 ½ Degrees.

The *other* Way of drawing a *Parallel of Declination*, is by ſeeking what is the *Meridian Altitude* for the 6th of *May*, and you will find it to be 55 Degrees. Set up therefore the Arch of 55 Degrees from H to D; and from the Point D draw D R a Parallel to E C, which ſhews the *Declination* and *Sun's Path* as before.

Thus though you have no *Scales* or *Tables* of the *Sun's Declination* at hand, you ſee it is poſſible to find the *Hour* and *Azimuth*, and many other Aſtronomical Problems by the *Analemma* for any Day in the Year. But this Method which I propoſed of performing them by finding the *Sun's Place in the Ecliptick* by any ſhort general Scale or Table, is liable to the Miſtake of near Half a Degree ſometimes.

Obſerve here, if you have by any Means obtained and drawn the *Sun's Path*, (*viz.*) D R for any given Day, you may find both the *Sun's Place in the Ecliptick* and its *Right Aſcenſion* by drawing C M the *Ecliptick*. For then C K will be the Sine of the *Sun's Place* or *Longitude* to the common Radius C M: And 6 K will be the Sine of the Sun's Diſtance on the *Equator* from the neareſt *Equinoctial* Point, but the Radius is 6 D: From hence you may eaſily compute its *Right Aſcenſion*.

*Note*, Though the little Schemes and Diagrams which belong to this Book, are ſufficient for a Demonſtration of the Truth and Reaſon of theſe Operations, yet if you have Occaſion to perform them in order to find the *Hour* or *Azimuth* with great Exactneſs, you muſt have a large flat Board, or very ſtiff Paſteboard with white Paper paſted on it, that you may draw a Semicircle

circle upon it of 9 or 10, or rather 12 Inches *Radius*; and the Lines muſt not be drawn with Ink, nor with a Pencil; for they cannot be drawn fine enough: But draw them only with the Point of the Compaſs; and you muſt obſerve every Part of the Operation with the greateſt Accuracy, and take the Sun's Place or Declination out of good Tables: For a little Error in ſome Places will make a foul and large Miſtake in the final Anſwer to the Problem.

Yet if the Sun be within ſeven or eight Days of either Side of either Solſtice, you may make the *Tropic of Cancer* or *Capricorn* ſerve for the Path of the Sun, without any ſenſible Error; for in 16 Days together at the Solſtices, its Declination does not alter above 12 or 15 Minutes: But near the *Equinox* you muſt be very exact; for the Declination alters greatly every Day at that Time of the Year.

There might be alſo various *Geographical* Practices or Problems, that relate to the Earthly Globe performed by the Aſſiſtance of the *Analemma*, and ſeveral other *Aſtronomical* Problems relating to the Sun and to the fixed Stars; but ſome of them are more troubleſome to perform; and what I have already written on this Subject is abundantly ſufficient to give the Learner an Acquaintance with the Nature and Reaſon of theſe Lines, and the Operations that are performed by them. And for my own Part I muſt confeſs, there is nothing has contributed to eſtabliſh all the Ideas of the Doctrine of the Sphere in my Mind, more than a perfect Acquaintance with the *Analemma*.

Problem XXII. *How to draw a Meridian Line, or a Line directly pointing to North and South on a Horizontal Plane by the Altitude or Azimuth of the Sun being given.*

At the ſame Time while one Perſon takes the *Altitude of the Sun* in order to find the *Azimuth* from Noon by it, let another hold up a Thread and Plummet in the *Sun-Beams* and mark any two diſtant Points in the *Shadow* as A B, Figure XXVI. and then draw the Line A B: Suppoſe the *Azimuth* at that Moment be found to be 35 Degrees, draw the Line A E at the Angle of 35 Degrees from A B, and that will be a true *Meridian Line.*

You muſt obſerve to ſet off the Angle on the proper Side of the Line of Shadow *Eaſtward* or *Weſtward*, according as you make your Obſervation in the Morning or in the Afternoon.

*Note*, Where you uſe a *Thread* and *Plummet*, remember that the larger and heavier your Plummet is, the ſteadier will your Shadow be, and you will draw it with greater Eaſe and Exactneſs.

In this and the following Operations to draw a *Meridian Line*, you muſt be ſure that your Plane be truly *Level* and *Horizontal*, or elſe your Performances will not be true.

### Problem XXIII. *To draw a Meridian Line on a Horizontal Plane, by a perpendicular Style.*

*Note*, That when I ſpeak of a *perpendicular Style*, I mean either of thoſe three Sorts of *Styles* before-mentioned in *Problem* I. (*viz.*) A *ſtraight Needle ſtuck into the Board perpendicularly*, as Figure XV. A *ſtraight or crooked Wyre ſtuck in ſloping at Random with the perpendicular Point* found under the Tip of it, as Figure XVI; or the *Braſs Priſm*, as Figure XVII. For what I call a *perpendicular Style* may be applied and aſcribed to either of theſe.

Make ſeveral parallel Circles or Arches, as Figure XXVII: In the Centre of them fix your *perpendicular Style* N C. Mark in the Morning what Point in any Circle the End of the Shadow touches, as A. In the Afternoon mark where the End of the Shadow touches the ſame Circle, as O: Divide the Arch A O juſt in halves by a Line drawn from the Centre, and that Line C M will be a true *Meridian Line*.

The Reaſon of this Practice is derived hence, (*viz.*) that the Sun's Altitude in the *Afternoon* is equal to the Sun's Altitude in the *Morning*, when it caſts a Shadow of the ſame Length: And at thoſe two Moments it is equally diſtant from the *Point of Noon* or the *South*, which is its higheſt Altitude: therefore a Line drawn exactly in the Middle between theſe two Points of Shadow, muſt be a *Meridian Line* or Point to the *North* and *South*.

This Problem may be performed by fixing your perpendicular Style firſt, and obſerving the Shadow A before you make the Circles, (eſpecially if you uſe the *Braſs Priſm*, or the ſloping Style with the perpendicular Point under it) then ſet one Foot of your Compaſſes in the perpendicular Point C, extend the other to A, and ſo make the Circle.

If you uſe the *Priſm* for a Style, you may mark a *Line* or *Angle* at the Foot of it where you firſt fix it, and place it right again, though you move it never ſo often.

It is very convenient to mark three or four Points of Shadow in the Morning, and accordingly draw three or four Arches or Circles, leſt the Sun ſhould not happen to ſhine, or you ſhould not happen to attend juſt at that Moment in the Afternoon when the Shadow touches that Circle on which you marked your firſt Point of Shadow in the Morning.

If you would be very exact in this Operation, you ſhould tarry till the Sun be gone one Minute further *Weſtward* in the Afternoon, *i. e.* till *one Minute* after the Shadow touches the ſame Circle, and then mark the Shadow; becauſe the Sun in ſix Hours Time (which is one Quarter of a Day) is gone *Eaſtward* on the Eclíptick in his Annual Courſe *one Minute* of Time, which is 15 Minutes (or one Quarter) of a Degree.

Problem XXIV. *To draw a Meridian Line on a Horizontal Plane by a Style or Needle ſet up at Random.*

Another Method near a-kin to the former is this: Set up a Needle or ſharp-pointed Style at Random, as N D, in Figure XXVIII. Fix it very faſt in the Board, and obſerve a Point of Shadow in the Morning as A. Then with a Pin ſtuck on the Tip of the Style N (without moving the Style) draw the Arch A S O: Mark the Point of Shadow O, in the Afternoon when it touches that Arch (or rather when it is one Minute paſt it.) Then draw the Line A O and biſſect it, or cut it in Halves by a perpendicular Line M E, which is a true *Meridian.*

*Note,* In this Method you have no Trouble of fixing a Style perpendicular, nor finding the Point directly under it for a Centre. But in this Method as well as in the former it is good to mark three or four Points of Shadow in the Morning, and draw Arches or Circles at them all, for the ſame Reaſon as before.

*Obſerve* here, That in theſe Methods of drawing a *Meridian Line* by the Shadow of the Tip of a Style, I think it is beſt generally to make your Obſervations between eight and ten a Clock in the Morning, and between two and four in the Afternoon. Indeed in the three Summer Months *May*, *June*, and *July*, you may perhaps make pretty good Obſervations an Hour earlier in the Morning, and later in the Afternoon; but at no Time of the Year ſhould you do it within an Hour of Noon, nor when the Sun is near the Horizon; for near Noon the Altitude of the Sun or the Length of Shadow varies exceeding little; and when the Sun is near the Horizon, the Point and Bounds of the Shadow are not full and ſtrong and diſtinct, nor can it be marked exactly.

Therefore if in the three Winter Months, *November*, *December*, or *January*, you make your Obſervation, you ſhould then do it half an Hour before or after ten a Clock in the Morning, and ſo much before or after two in the Afternoon; for otherwiſe the Sun will be either too near Noon, or too near the Horizon.

But in general, it may be adviſed that the Summer Half-year is far the beſt for Obſervation of Shadows in order to any Operations of this Kind.

### Problem XXV. *To draw a Meridian Line on an Equinoctial Day.*

On an *Equinoctial Day* or very near it, as the 8th, 9th, or 10th of *March*; or the 11th, 12th, or 13th of *September*, you may make a pretty true *Meridian Line* very eaſily thus by *Figure* XXIX.

Mark any two Points of Shadow as A B from a Needle C D ſet up at Random, (no Matter whether it be either upright or ſtraight.) Let thoſe two Shadows be at leaſt at the Diſtance of three or four Hours from each other, and it is beſt they ſhould be obſerved one in the Morning and the other about the ſame Diſtance from 12 in the Afternoon; and then draw the Line A B which repreſents the *Equinoctial Line*, and is the Path of the Sun that Day: Croſs it any where at right Angles, and M N, or O P, are *Meridian Lines.*

*Note,* It is beſt to mark ſeveral Shadows that Day, as *S*, *S*, *S*, and draw a right Line A *S S* B by thoſe which lie neareſt in a right Line, that you may be the more exact.

### Problem XXVI. *To draw a Meridian Line by a Point of a Shadow at Noon.*

If you have an exact Dial to whoſe Truth you can truſt, or a good Watch or Clock ſet exactly true by the Sun that Morning, then watch the Moment of 12 a Clock or Noon, and hold up a Thread and Plummet againſt the Sun, and mark the Line of Shadow on a Horizontal Plane, and that will be a true *Meridian Line.*

Or you may mark the Point or Edge of Shadow, by any Thing that ſtands truly perpendicular, at the Moment of 12 á Clock, and draw a *Meridian Line* by it.

Problem XXVII. *To draw a Meridian Line by a Horizontal Dial.*

If you have a Horizontal Dial which is not faſtened, and if it be made very true, then find the exact Hour and Minute by a Quadrant, or any other Dial, *&c.* at any Time of the Day, Morning or Afternoon; ſet the Horizontal Dial in the Place you deſign, to the true Hour and Minute; and the Hour Line of 12 will direct you to draw a *Meridian.*

Or if your Dial be ſquare, or have any Side exactly parallel to the Hour Line of 12, you may draw your *Meridian Line* by that Side or Edge of the Dial.

Problem XXVIII. *How to transfer a Meridian Line from one Place to another.*

There are ſeveral Ways of doing this.

Iſt *Way.* If it be on the ſame Plane, make a parallel Line to it, and that is a *true Meridian.*

IId *Way.* If it be required on a different Plane, ſet ſome good Horizontal Dial at the true Hour and Minute by your *Meridian Line* on the firſt Plane, then remove it and ſet it to the ſame Minute on the ſecond Plane, and by the 12 o'Clock Line mark your new *Meridian.*

*Note,* If the Sides or Edges of your Horizontal Dial are cut truly parallel to the 12 o'Clock Line, you may draw a *Meridian* by them as before.

IIId *Way.* Hold up a Thread and Plummet in the Sun, or ſet up a perpendicular Style near your Meridian Line any Time of the Day, and mark what Angle the Line of Shadow makes with that Meridian Line on your firſt Plane; then at the ſame Moment, as near as poſſible, project a Line of Shadow by the Thread, or another perpendicular Style on the new Plane, and ſet off the ſame Angle from it which will be a true Meridian.

*Note,* Two Perſons may perform this better than one.

## Problem XXIX. *How to draw a Line of Eaſt and Weſt on a Horizontal Plane.*

Where a *Meridian Line* can be drawn, make a Meridian Line firſt, and then croſs it at right Angles, which will be a true *Line of Eaſt and Weſt.*

But there are ſome Windows in a Houſe on which the Sun cannot ſhine at Noon; in ſuch a Caſe you may draw a Line of *Eaſt and Weſt* ſeveral Ways.

Iſt *Way.* You may uſe the ſame Practice which Problem XXII. directs, with this Difference, (*viz.*) inſtead of ſeeking the *Sun's Azimuth from the South*, ſeek its *Azimuth from Eaſt and Weſt*, and by a Line of Shadow from a Thread and Plummet marked at the ſame Time, ſet off the Angle of the Sun's Azimuth from *the Eaſt in the Morning*, or the *Weſt in the Afternoon.* A common Obſervation of the Courſe of the Sun will ſufficiently inform you on which Side of the Line of Shadow to ſet your Angle.

IId *Way.* You may uſe the ſecond Method of transferring a *Meridian Line* by a Horizontal Dial with this Difference, (*viz.*) inſtead of uſing the 12 *o'Clock Hour Line*, by which a *Meridian* was to be drawn, uſe the 6 *o'Clock Line*, which will be *Eaſt and Weſt*; for in a Horizontal Dial it ſtands always at right Angles with the *Meridian.*

IIId *Way.* The third Method of transferring a *Meridian Line* will ſerve here alſo; but with this Difference, (*viz.*) ſet off the

*Complement of the Angle*, which the Line of Shadow makes with your Meridian Line on the firſt Plane, inſtead of ſetting off the ſame *Angle*; and obſerve alſo to ſet it off on the contrary Side, that ſo it might make a right Angle with a Meridian Line if that could have come on the Plane.

Problem XXX. *How to uſe a Meridian Line.*

The various Uſes of a Meridian Line are theſe.

Iſt *Uſe*. A Meridian Line is neceſſary in order to draw an Horizontal Dial on the ſame Plane, or to fix an Horizontal Dial true if it be made before.

IId *Uſe*. A braſs Horizontal Dial may be removed from one Place to another in ſeveral Rooms of the ſame Houſe: and ſhew the Hour whereſoever the Sun comes, if either a *Meridian Line* or *Line of Eaſt and Weſt* be drawn in every Window, by which to ſet an Horizontal Dial true.

IIId *Uſe*. By a Thread and Plummet, or any perpendicular Pin, or Poſt caſting a Shadow preciſely along the Meridian Line, we find the Hour of 12, or the Point of Noon, and may ſet a Watch or Clock exactly true any Day in the Year, if we have no Dial at Hand.

IVth *Uſe.* It is neceſſary alſo to have ſome Meridian Line in order to find how a Houſe or Wall ſtands with regard to the four Quarters of the Heavens, *Eaſt*, *Weſt*, *North*, or *South*, which is called the *Bearing of a Houſe or Wall*, that we may determine what ſort of upright Dials may be fixed there, or what ſort of Fruit-Trees may be planted, or which Part of a Houſe or Garden is moſt expoſed to the Sun, or to the ſharp Winds.

Vth *Uſe.* By obſerving the Motion of the Clouds, or the Smoke, or a Vane or Weather-Cock, you cannot determine which Way the Wind blows, but by comparing it with a Meridian Line, or with a Line of *Eaſt* and *Weſt*.

When once you have got a true Meridian Line, and know which is the *South*, then the oppoſite Point muſt be *North*; and when your Face is to the *North*, the *Eaſt* is at your Right Hand, and the *Weſt* at your Left.

VIth *Uſe.* A Meridian Line will ſhew the Azimuth of the Sun at any time by holding up a Thread and Plummet in the Sun, and obſerving where the Line of Shadow croſſes it. Or the ſharp ſmooth Edge of an upright Style or Poſt will caſt a Shadow acroſs a Meridian Line, and ſhew the Sun's *Azimuth*.

VIIth *Uſe.* If you have a Meridian Line on a Horizontal Plane, you may draw a Circle on that as a Diameter, and divide it into 360 Degrees: Then ſet up a fixed or moveable perpendicular Style, and it will ſhew the Azimuth of the Sun at all Hours.

VIIIth *Uſe.* A perpendicular Style on a Meridian Line will ſhew the Sun's Meridian Altitude by the Tip of the Shadow according to *Problem* II. And thereby you may find the Latitude of any Place by *Problem* VII.

IXth *Uſe.* If you have a broad ſmooth Board with a Foot behind at the Bottom, to make it ſtand, ſuch as is deſcribed in *Prob.* XXIII. of the XIXth *Sect.* and if it be made to ſtand perpendicular on a Horizontal Plane by a Line and Plummet in the middle of it, you may ſet the Bottom or lower Edge of this Board in the *Meridian Line*, and by your Eye fixed at the Edge of the Board and projected along the flat Side, you may determine at Night, *what Stars are on the Meridian*; and then by the *Globe* (as in *Problem* XXXIII. and XXXIV. *Sect.* XIX.) or by an Inſtrument called a *Nocturnal*, you may find the Hour of the Night, or by an eaſy Calculation as in the XXXIIId. *Problem* of this XXth *Section.*

Problem XXXI. *How to know the Chief Stars, and to find the North Pole.*

If you know any one Star you may find out all the reſt by conſidering firſt ſome of the neareſt Stars that lie round it, whether they make a *Triangle* or a *Quadrangle*, *ſtraight Lines* or *Curves*, *right Angles* or *oblique Angles* with the known Star. This is eaſily done by comparing the Stars on the Globe (being rectified to the Hour of the Night) with the preſent Face of the Heavens, and the Situations of the Stars there, as in *Problem* XXXII. *Sect.* XIX.

And indeed it is by this Method that we not only learn to *know the Stars*, but even ſome Points in the Heavens where no Star is. I would inſtance only in the *North Pole*, which is eaſily found, if you firſt learn to know thoſe ſeven Stars which are called *Charles's Wain*, ſee *Figure* XXX. four of which in a Quadrangle may repreſent a *Cart* or *Waggon* *b*, *r*, *c*, *d*, and the three others repreſenting the *Horſes*.

*Note* alſo that the Star *a* is called *Alioth*, *d* is called *Dubbe*, *b* and *r* are called the two *Guards* or *Pointers*, for they point directly in a ſtraight Line to the *North Pole* *p*, which now is near 2 ¼ Degrees diſtant from the Star *s*, which is called the *North Pole Star*.

You may find the *North Pole* alſo by the Star *Alioth*, from which a ſtraight Line drawn to the *Pole Star* *s* goes through the *Pole Point* *p*, and leaves it at 2 ¼ Degrees Diſtance from the Pole Star.

You may find it alſo by the *little Star n*, which is the neareſt Star to the *Pole Star s*; for a Line drawn from *n* to *s* is the Hypothenuſe of a Right-angled Triangle, whoſe right Angle is in the *Pole Point p*.

Problem XXXII. *To find the Latitude by any Star that is on the North Meridian.*

It has been already ſhewn in the Xth *Problem of this Section*, how to find the *Latitude of a Place by the Meridian Altitude of a Star on the South Meridian*; but the Methods of Performance on the *North Meridian* are different.

The *firſt Way* is this. Take the Altitude of it when it is upon the North Meridian at 5 or 6 or 7 o'Clock in the Winter, then 12 Hours afterwards take its Altitude again, for it will be on the Meridian on the other Side of the Pole; ſubſtract half the Difference of thoſe two Altitudes from the greateſt Altitude, and the Remainder is the true *Elevation of the Pole, or Latitude of the Place*.

A *ſecond Way*. Obſerve when the Star *Alioth* comes to the Meridian under the Pole; then take the Height of the Pole Star, and out of it ſubſtract 2 ¼ Degrees (which is the Diſtance of the Pole Star from the Pole) the Remainder will be the true Elevation of the Pole, or the Latitude. The Reaſon of this Operation is evident by the xxxth Figure,

gure, for *Alioth* is on the Meridian under the Pole juſt when the *Pole Star* is on the Meridian above the Pole.

*Note*, The *Pole Star* is upon the Meridian above the Pole juſt at 12 o'Clock at Night on the 4th Day of *May*, and under the *Meridian* on the 5th Day of *November*: Fifteen Days after that it will be upon the Meridian at 11 o'Clock: Thirty Days after at 10 o'Clock: So that every Month it differs about two Hours.

Problem XXXIII. *To find the Hour of the Night by the Stars which are on the Meridian.*

If you have a Meridian Line drawn, and ſuch a Board as I have deſcribed under the 9th *Uſe of the Meridian Line*, you may exactly find when a Star is on the Meridian; and if you are well acquainted with the Stars, whereſoever you ſet up that Board upright on a Meridian Line, you will ſee what Star is on the Meridian. Suppoſe *Aldebaran* or the *Bull's Eye* on the 20th of *January* is on the South Part of the Meridian; then in ſome Tables find the Sun's and that Star's Right Aſcenſion, add the Complement of the Right Aſcenſion of the Sun for that Day, (*viz.*) 3 Hours 6 Minutes to the Right Aſcenſion of the Star 4 Hours 17 Minutes, and it makes 7 Hours 23 Minutes the true Hour of the Afternoon.

*Note*, If the Star be on the *North Part of the Meridian*, or below the *North* Pole, it is juſt the ſame Practice as on the *South* : for when any Star is on the Meridian, the Difference between the Sun's R. A. and that Star's R. A. is the Sun's true Hour, *i. e.* its Diſtance from 12 o' Clock at Noon or Midnight, at which Time the Sun is on the Meridian either *South* or *North*.

If you have no Meridian Line drawn, you may find within two or three Degrees what Stars are on the North Meridian thus; Hold up a String and Plummet and project it with your Eye over-right the *Pole Star*, or rather the *Pole Point*, and obſerve what other Stars are covered by it or cloſe to it, for theſe are on or near the Meridian.

Or it may be done with very little Error by ſtanding upright and looking ſtraight forward to the Pole Star, with a Stick, or Staff between your Hands, then raiſe up the Staff as ſtraight as you can over-right the Pole, and obſerve what Stars it covers in that Motion.

But theſe Methods are rude, and only ſerve for vulgar Purpoſes.

Problem XXXIV. *To find at what Hour of any Day a known Star will come upon the Meridian.*

Subſtract the Right Aſcenſion of the Sun for that Day from the Right Aſcenſion of the Star, the Remainder ſhews how many Hours after Noon the Star will be on the Meridian. Suppoſe I would know at what Hour the *Great Bear's Guards* or *Pointers* will be on the Meridian on the 27th of *April*; (for they come always to the Meridian nearly both at once.) The Right Aſcenſion of the Sun that Day is about two Hours 19 Minutes. The Right Aſcenſion of thoſe Stars is always ten Hours 24 Minutes. Subſtract the Sun's R. A. from the Star's R. A. the Remainder is five Minutes paſt eight a Clock at Night, and at that Time will the *Pointers be on the Meridian*.

| | *H.* | *M.* |
|---|---|---|
| Right Aſcen. of *Pointers* is ——— | 10 | 24 |
| Right Aſcen. of *Sun April* 27th is — | 2 | 19 |
| Time of Night —— — ——— | 8 | 5 |

*Note*, If the Sun's Right Aſcenſion be greater than the Right Aſcenſion of the Star, you muſt add 24 Hours to the Star's Right Aſcenſion, and then ſubſtract as before.

You may eaſily find alſo what Day any Star (ſuppoſe either of the *Pointers*) will be on the *Meridian* juſt when the Sun is there, (*viz.*) at 12 a Clock. Find in the Tables of the Right Aſcenſion of the Sun what Day that is wherein the Sun's Right Aſcenſion is the ſame (or very near the ſame) with that Star's, which is the 28th of *Auguſt*. The Sun's

Right Aſcenſion is 10 Hours 28 Minutes, then the Sun and Star are both on the Noon Meridian near the ſame time. But the Sun's Right Aſcenſion on the 23d of *February* is 22 Hours 24 Minutes. Therefore the Sun at that Time is in the Noon Meridian when the Star is in the Midnight Meridian, there being juſt 12 Hours Difference.

Thence you may reckon when the Star will be on the Meridian at any Time; for about 15 Days after it will be on the Meridian at 11 a Clock, 30 Days after at 10 a Clock. So that every Month it differs about two Hours; whence it comes to paſs that in 12 Months its Difference ariſing to 24 Hours it comes to be on the Meridian again at the ſame Time with the Sun.

Problem XXXV. *Having the Altitude of any Star given to find the Hour.*

To perform this Problem you ſhould never ſeek the Altitude of the Star when it is within an Hour or two of the Meridian, becauſe at that Time the Altitude varies ſo very little. When you have gotten the Altitude, then ſeek what is the Star's *Hour*, that is, its Equatorial Diſtance * from the Meridian at that Altitude, which may be done by the Globe, or any

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* The Sun or Star's *Horizontal* Diſtance from the Meridian is the *Azimuth:* It is the *Equatorial* Diſtance from the Meridian which is called the Sun or Star's *Hour*.

*Quadrant*, or by the *Analemma*, juſt as you would ſeek the Sun's Hour if its Altitude were given: After this, ſeek the Difference between the Sun's Right Aſcenſion for that Day and the Star's Right Aſcenſion, and by comparing this Difference with the Star's Hour you will find the true Hour of the Night.

*Note*, This Method of Operation though it be true in Theory, yet it is tedious and very troubleſome in Practice. The moſt uſual Ways therefore of finding the Hour of the Night by the Stars (whether they are on the Meridian or not) is by making uſe of a *large Globe*, or the Inſtrument called a *Nocturnal*, wherein the moſt remarkable Stars are fixed in their proper Degrees of Declination and Right Aſcenſion: And their Relation to the Sun's Place in the Ecliptick and to his Right Aſcenſion every Day in the Year being ſo obvious, makes the Operation of finding the true Hour very eaſy and pleaſant.

## SECT. XXI.

## *Tables of the Sun's Declination, and of the Declination and Right Aſcenſion of ſeveral remarkable fixed Stars, together with ſome Account how they are to be uſed.*

THE Reſolution of ſome of the *Aſtronomical Problems* by *Geometrical* Operations on the *Analemma* requires the Knowledge of the true *Place* of the Sun, his *Right Aſcenſion*, or his *Declination* at any given Day of the Year. But ſince the Knowledge of his *Declination* is of moſt eaſy and convenient Uſe herein, and ſince his true *Place* in the Ecliptick as well as his *Right Aſcenſion* may be nearly found Geometrically when his *Declination* is given, (except when near the Solſtices) I have not been at the Pains to draw out particular Tables of the *Sun's Place*, but contented my ſelf with Tables of *Declination* for every Day in the Year, and Tables of *Right Aſcenſion* for every tenth Day. Theſe are ſufficient for a young Learner's Practice in his firſt Rudiments of *Aſtronomy*. Thoſe who make a further Progreſs in this Science and would attain greater Exactneſs, muſt ſeek more particular Tables relating to the *Sun* in other larger Treatiſes.

Here let theſe few things be obſerved.

I. Theſe Tables ſhew the *Declination* of the Sun each Day at *Noon*; for it is then that the *Aſtronomer's Day* begins. If you would therefore know the Sun's Declination, ſuppoſe at *ſix* o'Clock in the Morning of any given Day, you muſt compare the Declination for that Day with the Sun's Declination the *foregoing* Day, and make a proportionable Allowance, (*viz.*) three fourth Parts of the Difference of thoſe two Declinations. If at *ſix* in the Afternoon, you muſt compare it with the following Day, and allow in the ſame manner one fourth Part.

II. Theſe Tables are fitted for the *Meridian of London.* If you would know therefore the Sun's Declination the ſame Day at Noon at *Port-Royal* in *Jamaica*, you muſt conſider the Difference of Longitude. Now that Place being about 75 Degrees *Weſtward* from *London*, that is, five Hours later in Time, it is but ſeven o'Clock in the Morning there when it is Noon at *London*: and you muſt make a proportionable Allowance for the Difference of the Sun's Declination by comparing it with that of the foregoing Day. If that Place had the ſame Longitude *Eaſtward* from *London*, it would be five o'Clock in the Afternoon there; and then you muſt compare the Sun's preſent Declination with that of the Day following, and make Allowance for the five Hours, *i. e.* almoſt ¼ of the Difference of the two Declinations. But if you would know the Sun's Declination at any Place and at any Hour of the Day at that Place; find what Hour it is at *London* at the given Hour at that Place, and find the Declination of the Sun for that Hour at *London* by *Note* the firſt.

*Note*, Theſe Allowances muſt be *added* or *ſubſtracted* according as the Sun's Declination is increaſing or decreaſing.

Yet in any of theſe Geometrical Operations the Difference of the Sun's Declination at other *Hours* of the Day or at other *Places* of the World is ſo exceeding ſmall that it is not ſufficient to make any remarkable Alterations, except when the Sun is near the Equinoxes; and then there may be ſome Allowances made for it in the manner I have deſcribed; nor even then is there any need of any ſuch Allowances except in Places which differ from *London* near 5 or 6 Hours in Longitude.

III. Let it be noted alſo, that as the *Place of the Sun*, ſo conſequently his *Declination* and *Right Aſcenſion* for every Day do vary ſomething every Year by reaſon of the odd *five Hours* and *forty nine Minutes* over and above 365 Days, of which the Solar Year conſiſts. Therefore it was proper to repreſent the Sun's Declination every Day for *four Years* together, (*viz.*) the three Years before *Leap-Year*, and the *Leap-Year* itſelf. For in the Circuit of thoſe four Years the Sun returns very nearly to the ſame Declination again on the ſame Day of the Year, becauſe thoſe odd five Hours and 49 Minutes do in four Years time make up 24 Hours, or a whole Day (wanting but four times eleven, *i. e.* 44 Minutes;)

which Day is ſuper-added to the Leap-Year, and makes the 29th of *February*, as hath been ſaid before.

It is true, that in a conſiderable Length of Time theſe Tables will want further Correction, becauſe of thoſe 44 Minutes which are really wanting to make up the ſuper-added Day in the Leap-Year. But theſe Tables will ſerve ſufficiently for any common Operations for forty or fifty Years to come, provided you always conſult that Table which is applicable to the current Year, whether it be a *Leap-Year*, or the *firſt*, the *ſecond* or the *third* Year after it.

IV. Obſerve alſo theſe Tables of the Sun's Declination are ſometimes reduced (as it were) to one *ſingle Scale*. And for this Purpoſe Men generally chooſe the Table of Declination for the Second after *Leap-Year*, and this is called the *Mean Declination*, that is, the Middle between the two *Leap-Years*. This is that Account of the *Sun's Place* and *Declination*, &c. which is made to be repreſented on all Mathematical Inſtruments, (*viz.*) *Globes*, *Quadrants*, *Projections of the Sphere*, and *graduated Scales*, &c. and this ſerves for ſuch common Geometrical Practices in Aſtronomy without any very remarkable Error.

Concerning the *Table of the fixed Stars*, let it be remembred that they move ſlowly round the Globe Eaſtward in Circles parallel to the Ecliptick, and therefore they increaſe their *Longitude* 50 Seconds of a Minute every Year, that is, one Degree in ſeventy two Years. But their *Latitude* never alters, becauſe they always keep at the ſame Diſtance from the *Ecliptick*.

Let it be noted alſo, that this ſlow Motion of the *fixed Stars* cauſes their *Declination* and their *Right Aſcenſion* to vary (though very little) every Year. Their *Right Aſcenſion* neceſſarily changes becauſe their *Longitude* changes, though not exactly in the ſame Quantity. And though their *Latitude* never alters, becauſe *Latitude* is their Diſtance from the *Ecliptick*, yet their *Declination* muſt alter a little, becauſe it is their Diſtance from the *Equator*. But the Tables of their *Right Aſcenſion*, which I have here exhibited, will ſerve for any common Practices for at leaſt twenty Years to come, and their *Declination* for near fifty Years, without any ſenſible Error in ſuch Aſtronomical Eſſays as theſe.

It may be proper here to give Notice to Learners, that the ſame Stars may have *North Latitude* and *South Declination*; ſuch are all thoſe that lie between the *Equator* and the *Southern* half of the *Ecliptick*: But all thoſe Stars which lie between the *Equator* and the *Northern* half of the *Ecliptick*, have *South Latitude* and *North Declination*.

*A Table of the Sun's Declination for the Year 1753, being the Firſt after Leap-Year, which will ſerve for near 50 Years.*

| Day. | Janu. S. | | Febr. S. | | March S.* | | April N. | | May N. | | June N. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. |
| 1 | 22 | 59 | 16 | 57 | 07 | 24 | 04 | 43 | 15 | 12 | 22 | 08 |
| 2 | 22 | 53 | 16 | 40 | 07 | 01 | 05 | 06 | 15 | 30 | 22 | 16 |
| 3 | 22 | 48 | 16 | 22 | 06 | 38 | 05 | 29 | 15 | 48 | 22 | 23 |
| 4 | 22 | 41 | 16 | 04 | 06 | 15 | 05 | 52 | 16 | 05 | 22 | 30 |
| 5 | 22 | 35 | 15 | 46 | 05 | 51 | 06 | 14 | 16 | 23 | 22 | 36 |
| 6 | 22 | 27 | 15 | 28 | 05 | 28 | 06 | 37 | 16 | 40 | 22 | 43 |
| 7 | 22 | 19 | 15 | 09 | 05 | 05 | 07 | 00 | 16 | 56 | 22 | 49 |
| 8 | 22 | 11 | 14 | 50 | 04 | 42 | 07 | 22 | 17 | 13 | 22 | 54 |
| 9 | 22 | 03 | 14 | 31 | 04 | 18 | 07 | 44 | 17 | 28 | 22 | 59 |
| 10 | 21 | 54 | 14 | 11 | 03 | 55 | 08 | 07 | 17 | 44 | 23 | 04 |
| 11 | 21 | 45 | 13 | 52 | 03 | 31 | 08 | 29 | 17 | 59 | 23 | 08 |
| 12 | 21 | 35 | 13 | 32 | 03 | 07 | 08 | 51 | 18 | 14 | 23 | 12 |
| 13 | 21 | 25 | 13 | 12 | 02 | 44 | 09 | 12 | 18 | 29 | 23 | 16 |
| 14 | 21 | 14 | 12 | 52 | 02 | 20 | 09 | 34 | 18 | 44 | 23 | 19 |
| 15 | 21 | 03 | 12 | 31 | 01 | 57 | 09 | 55 | 18 | 58 | 23 | 22 |
| 16 | 20 | 52 | 12 | 10 | 01 | 33 | 10 | 17 | 19 | 12 | 23 | 24 |
| 17 | 20 | 39 | 11 | 49 | 01 | 09 | 10 | 37 | 19 | 26 | 23 | 25 |
| 18 | 20 | 27 | 11 | 28 | 00 | 45 | 10 | 58 | 19 | 39 | 23 | 26 |
| 19 | 20 | 14 | 11 | 06 | 00 | 22 | 11 | 19 | 19 | 52 | 23 | 27 |
| 20 | 20 | 01 | 10 | 45 | N. | 02 | 11 | 39 | 20 | 05 | 23 | 28 |
| 21 | 19 | 48 | 10 | 22 | 00 | 25 | 12 | 00 | 20 | 17 | 23 | 29 |
| 22 | 19 | 34 | 10 | 00 | 00 | 48 | 12 | 20 | 20 | 29 | 23 | 28 |
| 23 | 19 | 20 | 09 | 39 | 01 | 12 | 12 | 40 | 20 | 40 | 23 | 27 |
| 24 | 19 | 06 | 09 | 16 | 01 | 36 | 13 | 00 | 20 | 51 | 23 | 26 |
| 25 | 18 | 51 | 08 | 54 | 01 | 59 | 13 | 19 | 21 | 02 | 23 | 25 |
| 26 | 18 | 36 | 08 | 31 | 02 | 23 | 13 | 39 | 21 | 12 | 23 | 24 |
| 27 | 18 | 21 | 08 | 09 | 02 | 46 | 13 | 58 | 21 | 22 | 23 | 22 |
| 28 | 18 | 05 | 07 | 46 | 03 | 10 | 14 | 17 | 21 | 32 | 23 | 19 |
| 29 | 17 | 49 | | | 03 | 33 | 14 | 36 | 21 | 42 | 23 | 15 |
| 30 | 17 | 31 | | | 03 | 56 | 14 | 54 | 21 | 51 | 23 | 11 |
| 31 | 17 | 14 | | | 04 | 19 | | | 21 | 59 | | |

*A Table of the Sun's Declination for the Year* 1753, *being the Firſt after Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | July N. | | Aug. N. | | Sept. N.* | | Oct. S. | | Nov. S. | | Dec. S. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. |
| 1 | 23 | 07 | 17 | 59 | 08 | 10 | 03 | 20 | 14 | 36 | 21 | 55 |
| 2 | 23 | 03 | 17 | 43 | 07 | 48 | 03 | 43 | 14 | 55 | 22 | 04 |
| 3 | 22 | 59 | 17 | 28 | 07 | 26 | 04 | 07 | 15 | 14 | 22 | 13 |
| 4 | 22 | 54 | 17 | 12 | 07 | 04 | 04 | 30 | 15 | 32 | 22 | 21 |
| 5 | 22 | 48 | 16 | 56 | 06 | 42 | 04 | 53 | 15 | 51 | 22 | 28 |
| 6 | 22 | 42 | 16 | 39 | 06 | 19 | 05 | 16 | 16 | 09 | 22 | 36 |
| 7 | 22 | 36 | 16 | 23 | 05 | 57 | 05 | 39 | 16 | 27 | 22 | 42 |
| 8 | 22 | 29 | 16 | 05 | 05 | 34 | 06 | 02 | 16 | 44 | 22 | 48 |
| 9 | 22 | 22 | 15 | 47 | 05 | 11 | 06 | 25 | 17 | 01 | 22 | 54 |
| 10 | 22 | 15 | 15 | 30 | 04 | 49 | 06 | 48 | 17 | 18 | 23 | 00 |
| 11 | 22 | 06 | 15 | 12 | 04 | 26 | 07 | 11 | 17 | 35 | 23 | 05 |
| 12 | 21 | 58 | 14 | 54 | 04 | 03 | 07 | 34 | 17 | 51 | 23 | 09 |
| 13 | 21 | 49 | 14 | 36 | 03 | 40 | 07 | 56 | 18 | 07 | 23 | 13 |
| 14 | 21 | 40 | 14 | 18 | 03 | 17 | 08 | 19 | 18 | 22 | 23 | 17 |
| 15 | 21 | 31 | 13 | 59 | 02 | 54 | 08 | 41 | 18 | 38 | 23 | 20 |
| 16 | 21 | 21 | 13 | 40 | 02 | 30 | 09 | 03 | 18 | 53 | 23 | 23 |
| 17 | 21 | 11 | 13 | 21 | 02 | 07 | 09 | 25 | 19 | 08 | 23 | 25 |
| 18 | 21 | 01 | 13 | 02 | 01 | 44 | 09 | 47 | 19 | 22 | 23 | 26 |
| 19 | 20 | 50 | 12 | 42 | 01 | 20 | 10 | 09 | 19 | 36 | 23 | 27 |
| 20 | 20 | 39 | 12 | 22 | 00 | 58 | 10 | 31 | 19 | 50 | 23 | 28 |
| 21 | 20 | 28 | 12 | 02 | 00 | 34 | 10 | 52 | 20 | 03 | 23 | 29 |
| 22 | 20 | 15 | 11 | 42 | 00 | 10 | 11 | 14 | 20 | 16 | 23 | 28 |
| 23 | 20 | 03 | 11 | 22 | S. | 12 | 11 | 34 | 20 | 29 | 23 | 28 |
| 24 | 19 | 50 | 11 | 01 | 00 | 36 | 11 | 55 | 20 | 41 | 23 | 27 |
| 25 | 19 | 37 | 10 | 41 | 00 | 59 | 12 | 16 | 20 | 53 | 23 | 25 |
| 26 | 19 | 24 | 10 | 20 | 01 | 23 | 12 | 36 | 21 | 04 | 23 | 23 |
| 27 | 19 | 11 | 09 | 59 | 01 | 46 | 12 | 57 | 21 | 15 | 23 | 21 |
| 28 | 18 | 57 | 09 | 37 | 02 | 10 | 13 | 17 | 21 | 25 | 23 | 18 |
| 29 | 18 | 43 | 09 | 16 | 02 | 33 | 13 | 37 | 21 | 36 | 23 | 14 |
| 30 | 18 | 28 | 08 | 55 | 02 | 57 | 13 | 57 | 21 | 46 | 23 | 10 |
| 31 | 18 | 14 | 08 | 33 | | | 14 | 16 | | | 23 | 05 |

*A Table of the Sun's Declination for the Year* 1754, *being the ſecond after Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | Janu. S. | Febr. S. | March S.* | April N. | May N. | June N. |
|---|---|---|---|---|---|---|
| | d. m. | d. m. | d. m. | d. m. | d. m. | d. m. |
| 1 | 23 01 | 17 01 | 07 29 | 04 37 | 15 08 | 22 06 |
| 2 | 22 55 | 16 44 | 07 06 | 05 00 | 15 26 | 22 14 |
| 3 | 22 50 | 16 27 | 06 43 | 05 23 | 15 44 | 22 21 |
| 4 | 22 44 | 16 09 | 06 20 | 05 46 | 16 01 | 22 28 |
| 5 | 22 37 | 15 51 | 05 57 | 06 09 | 16 19 | 22 35 |
| 6 | 22 29 | 15 32 | 05 34 | 06 32 | 16 37 | 22 41 |
| 7 | 22 21 | 15 14 | 05 11 | 06 54 | 16 51 | 22 47 |
| 8 | 22 13 | 14 55 | 04 47 | 07 17 | 17 08 | 22 53 |
| 9 | 22 05 | 14 35 | 04 24 | 07 39 | 17 24 | 22 58 |
| 10 | 21 56 | 14 16 | 04 00 | 08 01 | 17 40 | 23 03 |
| 11 | 21 47 | 13 56 | 03 37 | 08 23 | 17 55 | 23 07 |
| 12 | 21 37 | 13 37 | 03 13 | 08 45 | 18 11 | 23 11 |
| 13 | 21 27 | 13 16 | 02 50 | 09 07 | 18 26 | 23 15 |
| 14 | 21 17 | 12 56 | 02 26 | 09 29 | 18 40 | 23 18 |
| 15 | 21 06 | 12 36 | 02 02 | 09 50 | 18 55 | 23 21 |
| 16 | 20 55 | 12 15 | 01 39 | 10 11 | 19 09 | 23 23 |
| 17 | 20 42 | 11 54 | 01 15 | 10 32 | 19 22 | 23 25 |
| 18 | 20 30 | 11 33 | 00 51 | 10 53 | 19 36 | 23 26 |
| 19 | 20 17 | 11 12 | 00 28 | 11 14 | 19 49 | 23 27 |
| 20 | 20 04 | 10 49 | 00 04 | 11 34 | 20 02 | 23 28 |
| 21 | 19 51 | 10 27 | N. 19 | 11 55 | 20 14 | 23 29 |
| 22 | 19 38 | 10 06 | 00 43 | 12 15 | 20 26 | 23 29 |
| 23 | 19 24 | 09 44 | 01 06 | 12 35 | 20 38 | 23 28 |
| 24 | 19 09 | 09 22 | 01 30 | 12 55 | 20 49 | 23 27 |
| 25 | 18 55 | 08 59 | 01 53 | 13 15 | 20 59 | 23 26 |
| 26 | 18 40 | 08 37 | 02 17 | 13 34 | 21 10 | 23 24 |
| 27 | 18 24 | 08 14 | 02 40 | 13 53 | 21 20 | 23 21 |
| 28 | 18 08 | 07 52 | 03 04 | 14 12 | 21 30 | 23 18 |
| 29 | 17 52 | | 03 27 | 14 31 | 21 39 | 23 15 |
| 30 | 17 36 | | 03 51 | 14 50 | 21 49 | 23 12 |
| 31 | 17 18 | | 04 14 | | 21 57 | |

*A Table of the Sun's Declination for the Year* 1754, *being the firſt after Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | July N. | | Aug. N. | | Sept. N.* | | Oct. S. | | Nov. S. | | Dec. S. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. | d. | m |
| 1 | 23 | 08 | 18 | 02 | 08 | 15 | 03 | 14 | 14 | 31 | 21 | 53 |
| 2 | 23 | 04 | 17 | 47 | 07 | 54 | 03 | 38 | 14 | 50 | 22 | 02 |
| 3 | 23 | 00 | 17 | 32 | 07 | 31 | 04 | 01 | 15 | 09 | 22 | 11 |
| 4 | 22 | 55 | 17 | 16 | 07 | 09 | 04 | 24 | 15 | 28 | 22 | 19 |
| 5 | 22 | 49 | 17 | 00 | 06 | 47 | 04 | 47 | 15 | 46 | 22 | 27 |
| 6 | 22 | 44 | 16 | 43 | 06 | 25 | 05 | 11 | 16 | 04 | 22 | 34 |
| 7 | 22 | 37 | 16 | 26 | 06 | 02 | 05 | 34 | 16 | 22 | 22 | 40 |
| 8 | 22 | 31 | 16 | 09 | 05 | 40 | 05 | 57 | 16 | 40 | 22 | 47 |
| 9 | 22 | 24 | 15 | 52 | 05 | 17 | 06 | 20 | 16 | 57 | 22 | 53 |
| 10 | 22 | 17 | 15 | 34 | 04 | 54 | 06 | 43 | 17 | 14 | 22 | 58 |
| 11 | 22 | 09 | 15 | 17 | 04 | 31 | 07 | 05 | 17 | 31 | 23 | 03 |
| 12 | 22 | 00 | 14 | 59 | 04 | 09 | 07 | 28 | 17 | 48 | 23 | 08 |
| 13 | 21 | 51 | 14 | 40 | 03 | 45 | 07 | 51 | 18 | 04 | 23 | 12 |
| 14 | 21 | 43 | 14 | 22 | 03 | 22 | 08 | 13 | 18 | 19 | 23 | 16 |
| 15 | 21 | 33 | 14 | 03 | 02 | 59 | 08 | 36 | 18 | 34 | 23 | 19 |
| 16 | 21 | 24 | 13 | 45 | 02 | 36 | 08 | 58 | 18 | 49 | 23 | 22 |
| 17 | 21 | 14 | 13 | 26 | 02 | 13 | 09 | 20 | 19 | 04 | 23 | 24 |
| 18 | 21 | 03 | 13 | 06 | 01 | 49 | 09 | 42 | 19 | 19 | 23 | 26 |
| 19 | 20 | 53 | 12 | 47 | 01 | 26 | 10 | 04 | 19 | 33 | 23 | 27 |
| 20 | 20 | 42 | 12 | 27 | 01 | 03 | 10 | 25 | 19 | 47 | 23 | 28 |
| 21 | 20 | 30 | 12 | 07 | 00 | 39 | 10 | 46 | 20 | 00 | 23 | 29 |
| 22 | 20 | 18 | 11 | 47 | 00 | 16 | 11 | 08 | 20 | 13 | 23 | 29 |
| 23 | 20 | 06 | 11 | 27 | S. | 07 | 11 | 29 | 20 | 26 | 23 | 28 |
| 24 | 19 | 53 | 11 | 06 | 00 | 30 | 11 | 51 | 20 | 38 | 23 | 27 |
| 25 | 19 | 40 | 10 | 46 | 00 | 54 | 12 | 11 | 20 | 50 | 23 | 26 |
| 26 | 19 | 27 | 10 | 25 | 01 | 17 | 12 | 31 | 21 | 02 | 23 | 24 |
| 27 | 19 | 14 | 10 | 04 | 01 | 41 | 12 | 52 | 21 | 13 | 23 | 21 |
| 28 | 19 | 00 | 09 | 43 | 02 | 04 | 13 | 12 | 21 | 23 | 23 | 18 |
| 29 | 18 | 46 | 09 | 21 | 02 | 27 | 13 | 32 | 21 | 33 | 23 | 15 |
| 30 | 18 | 32 | 08 | 59 | 02 | 51 | 13 | 52 | 21 | 43 | 23 | 11 |
| 31 | 18 | 17 | 08 | 37 | | | 14 | 12 | | | 23 | 06 |

*A Table of the Sun's Declination for the Year* 1755, *being the Third after Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | Janu. S. | | Febr. S. | | March S.* | | April N. | | May N. | | June N. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. |
| 1 | 23 | 02 | 17 | 06 | 07 | 35 | 04 | 30 | 15 | 04 | 22 | 04 |
| 2 | 22 | 57 | 16 | 48 | 07 | 12 | 04 | 54 | 15 | 22 | 22 | 12 |
| 3 | 22 | 51 | 16 | 31 | 06 | 49 | 05 | 17 | 15 | 39 | 22 | 20 |
| 4 | 22 | 45 | 16 | 13 | 06 | 26 | 05 | 39 | 15 | 57 | 22 | 27 |
| 5 | 22 | 38 | 15 | 55 | 06 | 03 | 06 | 03 | 16 | 14 | 22 | 33 |
| 6 | 22 | 31 | 15 | 37 | 05 | 40 | 06 | 26 | 16 | 31 | 22 | 39 |
| 7 | 22 | 23 | 15 | 18 | 05 | 16 | 06 | 49 | 16 | 48 | 22 | 46 |
| 8 | 22 | 15 | 14 | 59 | 04 | 53 | 07 | 11 | 17 | 04 | 22 | 51 |
| 9 | 22 | 07 | 14 | 40 | 04 | 29 | 07 | 34 | 17 | 20 | 22 | 57 |
| 10 | 21 | 58 | 14 | 21 | 04 | 06 | 07 | 56 | 17 | 36 | 23 | 02 |
| 11 | 21 | 49 | 14 | 01 | 03 | 43 | 08 | 18 | 17 | 52 | 23 | 06 |
| 12 | 21 | 40 | 13 | 41 | 03 | 19 | 08 | 40 | 18 | 07 | 23 | 10 |
| 13 | 21 | 30 | 13 | 21 | 02 | 55 | 09 | 02 | 18 | 22 | 23 | 14 |
| 14 | 21 | 19 | 13 | 01 | 02 | 32 | 09 | 24 | 18 | 37 | 23 | 17 |
| 15 | 21 | 09 | 12 | 41 | 02 | 08 | 09 | 45 | 18 | 51 | 23 | 20 |
| 16 | 20 | 57 | 12 | 20 | 01 | 44 | 10 | 06 | 19 | 05 | 23 | 23 |
| 17 | 20 | 45 | 11 | 59 | 01 | 21 | 10 | 27 | 19 | 19 | 23 | 25 |
| 18 | 20 | 33 | 11 | 38 | 00 | 57 | 10 | 48 | 19 | 33 | 23 | 26 |
| 19 | 20 | 20 | 11 | 17 | 00 | 33 | 11 | 09 | 19 | 46 | 23 | 27 |
| 20 | 20 | 08 | 10 | 55 | 00 | 10 | 11 | 29 | 19 | 59 | 23 | 28 |
| 21 | 19 | 54 | 10 | 33 | N. | 13 | 11 | 50 | 20 | 11 | 23 | 29 |
| 22 | 19 | 41 | 10 | 11 | 00 | 37 | 12 | 10 | 20 | 23 | 23 | 29 |
| 23 | 19 | 27 | 09 | 49 | 01 | 00 | 12 | 30 | 20 | 35 | 23 | 28 |
| 24 | 19 | 13 | 09 | 27 | 01 | 24 | 12 | 50 | 20 | 46 | 23 | 27 |
| 25 | 18 | 58 | 09 | 05 | 01 | 48 | 13 | 10 | 20 | 57 | 23 | 26 |
| 26 | 18 | 43 | 08 | 42 | 02 | 11 | 13 | 29 | 21 | 07 | 23 | 24 |
| 27 | 18 | 28 | 08 | 20 | 02 | 35 | 13 | 49 | 21 | 18 | 23 | 22 |
| 28 | 18 | 12 | 07 | 57 | 02 | 58 | 14 | 08 | 21 | 28 | 23 | 19 |
| 29 | 17 | 56 | | | 03 | 22 | 14 | 27 | 21 | 37 | 23 | 16 |
| 30 | 17 | 40 | | | 03 | 45 | 14 | 45 | 21 | 46 | 23 | 13 |
| 31 | 17 | 23 | | | 04 | 08 | | | 21 | 55 | | |

*A Table of the Sun's Declination for the Year 1755, being the Third after Leap-Year, which will ſerve for near 50 Years.*

| Day. | July N. | | Aug. N. | | Sept. N.* | | Oct. S. | | Nov. S. | | Dec. S. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m | d. | m. | d. | m. | d. | m. |
| 1 | 23 | 09 | 18 | 06 | 08 | 21 | 03 | 09 | 14 | 26 | 21 | 50 |
| 2 | 23 | 05 | 17 | 51 | 07 | 59 | 03 | 32 | 14 | 46 | 22 | 00 |
| 3 | 23 | 01 | 17 | 35 | 07 | 37 | 03 | 55 | 15 | 05 | 22 | 09 |
| 4 | 22 | 56 | 17 | 20 | 07 | 15 | 04 | 19 | 15 | 23 | 22 | 17 |
| 5 | 22 | 51 | 17 | 04 | 06 | 53 | 04 | 42 | 15 | 42 | 22 | 24 |
| 6 | 22 | 45 | 16 | 47 | 06 | 30 | 05 | 05 | 16 | 00 | 22 | 31 |
| 7 | 22 | 39 | 16 | 30 | 06 | 08 | 05 | 28 | 16 | 18 | 22 | 38 |
| 8 | 22 | 32 | 16 | 13 | 05 | 45 | 05 | 51 | 16 | 36 | 22 | 45 |
| 9 | 22 | 26 | 15 | 56 | 05 | 22 | 06 | 14 | 16 | 53 | 22 | 51 |
| 10 | 22 | 18 | 15 | 38 | 04 | 00 | 06 | 37 | 17 | 10 | 22 | 57 |
| 11 | 22 | 10 | 15 | 21 | 04 | 37 | 07 | 00 | 17 | 26 | 23 | 02 |
| 12 | 22 | 02 | 15 | 03 | 04 | 14 | 07 | 23 | 17 | 43 | 23 | 07 |
| 13 | 21 | 53 | 14 | 45 | 03 | 51 | 07 | 45 | 17 | 59 | 23 | 11 |
| 14 | 21 | 45 | 14 | 27 | 03 | 28 | 08 | 07 | 18 | 15 | 23 | 15 |
| 15 | 21 | 36 | 14 | 08 | 03 | 05 | 08 | 29 | 18 | 30 | 23 | 18 |
| 16 | 21 | 26 | 13 | 49 | 02 | 42 | 08 | 51 | 18 | 46 | 23 | 21 |
| 17 | 21 | 16 | 13 | 30 | 02 | 18 | 09 | 14 | 19 | 01 | 23 | 23 |
| 18 | 21 | 06 | 13 | 11 | 01 | 55 | 09 | 36 | 19 | 15 | 23 | 25 |
| 19 | 20 | 55 | 12 | 51 | 01 | 32 | 09 | 57 | 19 | 30 | 23 | 27 |
| 20 | 20 | 44 | 12 | 32 | 01 | 08 | 10 | 19 | 19 | 43 | 23 | 28 |
| 21 | 20 | 33 | 12 | 12 | 00 | 45 | 10 | 41 | 19 | 57 | 23 | 29 |
| 22 | 20 | 21 | 11 | 52 | 00 | 21 | 11 | 02 | 20 | 10 | 23 | 29 |
| 23 | 20 | 09 | 11 | 32 | S. | 02 | 11 | 23 | 20 | 23 | 23 | 28 |
| 24 | 19 | 56 | 11 | 11 | 00 | 25 | 11 | 45 | 20 | 35 | 23 | 27 |
| 25 | 19 | 44 | 10 | 51 | 00 | 48 | 12 | 05 | 20 | 47 | 23 | 26 |
| 26 | 19 | 31 | 10 | 30 | 01 | 11 | 12 | 26 | 20 | 58 | 23 | 24 |
| 27 | 19 | 17 | 10 | 09 | 01 | 35 | 12 | 47 | 21 | 09 | 23 | 21 |
| 28 | 19 | 04 | 09 | 48 | 01 | 58 | 13 | 07 | 21 | 20 | 23 | 18 |
| 29 | 18 | 50 | 09 | 26 | 02 | 22 | 13 | 27 | 21 | 31 | 23 | 15 |
| 30 | 18 | 35 | 09 | 04 | 02 | 45 | 13 | 47 | 21 | 41 | 23 | 12 |
| 31 | 18 | 21 | 08 | 42 | | | 14 | 07 | | | 23 | 08 |

*A Table of the Sun's Declination for the Year* 1756, *being Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | Janu. S. | | Febr. S. | | March S.* | | April N. | | May N. | | June N. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. | d. | m. |
| 1 | 23 | 03 | 17 | 10 | 07 | 17 | 04 | 49 | 15 | 17 | 22 | 10 |
| 2 | 22 | 58 | 16 | 53 | 06 | 54 | 05 | 12 | 15 | 35 | 22 | 17 |
| 3 | 22 | 52 | 16 | 35 | 06 | 28 | 05 | 35 | 15 | 52 | 22 | 24 |
| 4 | 22 | 46 | 16 | 17 | 06 | 08 | 05 | 58 | 16 | 09 | 22 | 31 |
| 5 | 22 | 39 | 15 | 59 | 05 | 45 | 06 | 21 | 16 | 26 | 22 | 38 |
| 6 | 22 | 32 | 15 | 41 | 05 | 22 | 06 | 43 | 16 | 43 | 22 | 44 |
| 7 | 22 | 25 | 15 | 23 | 04 | 59 | 07 | 06 | 17 | 00 | 22 | 50 |
| 8 | 22 | 17 | 15 | 04 | 04 | 35 | 07 | 28 | 17 | 16 | 22 | 56 |
| 9 | 22 | 09 | 14 | 45 | 04 | 12 | 07 | 50 | 17 | 32 | 23 | 01 |
| 10 | 22 | 01 | 14 | 26 | 03 | 48 | 08 | 13 | 17 | 48 | 23 | 05 |
| 11 | 21 | 52 | 14 | 06 | 03 | 25 | 08 | 35 | 18 | 03 | 23 | 10 |
| 12 | 21 | 42 | 13 | 46 | 03 | 01 | 08 | 57 | 18 | 18 | 23 | 14 |
| 13 | 21 | 32 | 13 | 26 | 02 | 37 | 09 | 18 | 18 | 33 | 23 | 17 |
| 14 | 21 | 22 | 13 | 06 | 02 | 14 | 09 | 39 | 18 | 48 | 23 | 20 |
| 15 | 21 | 11 | 12 | 46 | 01 | 50 | 10 | 00 | 19 | 02 | 23 | 22 |
| 16 | 21 | 00 | 12 | 25 | 01 | 26 | 10 | 22 | 19 | 16 | 23 | 24 |
| 17 | 20 | 49 | 12 | 04 | 01 | 03 | 10 | 43 | 19 | 29 | 23 | 26 |
| 18 | 20 | 37 | 11 | 43 | 00 | 39 | 11 | 04 | 19 | 42 | 23 | 27 |
| 19 | 20 | 24 | 11 | 22 | 00 | 16 | 11 | 24 | 19 | 55 | 23 | 28 |
| 20 | 20 | 11 | 10 | 00 | N. | 07 | 11 | 45 | 20 | 07 | 23 | 28 |
| 21 | 19 | 58 | 10 | 38 | 00 | 31 | 12 | 05 | 20 | 19 | 23 | 29 |
| 22 | 19 | 44 | 10 | 16 | 00 | 55 | 12 | 25 | 20 | 31 | 23 | 28 |
| 23 | 19 | 30 | 09 | 54 | 01 | 18 | 12 | 45 | 20 | 43 | 23 | 28 |
| 24 | 19 | 16 | 09 | 32 | 01 | 42 | 13 | 05 | 20 | 54 | 23 | 27 |
| 25 | 19 | 02 | 09 | 10 | 02 | 06 | 13 | 25 | 21 | 05 | 23 | 25 |
| 26 | 18 | 47 | 08 | 48 | 02 | 29 | 13 | 44 | 21 | 15 | 23 | 23 |
| 27 | 18 | 32 | 08 | 25 | 02 | 53 | 14 | 03 | 21 | 25 | 23 | 20 |
| 28 | 18 | 16 | 08 | 03 | 03 | 16 | 14 | 22 | 21 | 35 | 23 | 17 |
| 29 | 18 | 00 | 07 | 40 | 03 | 39 | 14 | 41 | 21 | 44 | 23 | 14 |
| 30 | 17 | 44 | | | 04 | 03 | 14 | 59 | 21 | 53 | 23 | 10 |
| 31 | 17 | 27 | | | 04 | 26 | | | 22 | 02 | | |

*A Table of the Sun's Declination for the Year* 1756, *being Leap-Year, which will ſerve for near* 50 *Years.*

| Day. | July N. | Aug. N. | Sept. N.* | Oct. S. | Nov. S. | Dec. S. |
|---|---|---|---|---|---|---|
| | d. m. | d. m. | d. m. | d. m. | d. m. | d. m. |
| 1 | 23 06 | 17 55 | 08 04 | 03 26 | 14 41 | 21 57 |
| 2 | 23 02 | 17 39 | 07 42 | 03 50 | 15 00 | 22 06 |
| 3 | 22 57 | 17 24 | 07 20 | 04 13 | 15 19 | 22 15 |
| 4 | 22 52 | 17 08 | 06 58 | 04 36 | 15 37 | 22 23 |
| 5 | 22 46 | 16 51 | 06 36 | 04 59 | 15 56 | 22 30 |
| 6 | 22 40 | 16 34 | 06 13 | 05 23 | 16 14 | 22 37 |
| 7 | 22 34 | 16 17 | 05 51 | 05 46 | 16 31 | 22 43 |
| 8 | 22 27 | 16 00 | 05 28 | 06 09 | 16 49 | 22 50 |
| 9 | 22 20 | 15 43 | 05 05 | 06 32 | 17 06 | 22 56 |
| 10 | 22 12 | 15 25 | 04 42 | 06 54 | 17 23 | 23 01 |
| 11 | 22 04 | 15 07 | 04 20 | 07 17 | 17 39 | 23 06 |
| 12 | 21 55 | 14 49 | 03 57 | 07 40 | 17 55 | 23 10 |
| 13 | 21 47 | 14 31 | 03 33 | 08 02 | 18 11 | 23 14 |
| 14 | 21 38 | 14 13 | 03 10 | 08 25 | 18 27 | 23 18 |
| 15 | 21 28 | 13 54 | 02 47 | 08 47 | 18 42 | 23 21 |
| 16 | 21 19 | 13 35 | 02 24 | 09 09 | 18 57 | 23 23 |
| 17 | 21 08 | 13 16 | 02 01 | 09 31 | 19 12 | 23 25 |
| 18 | 20 58 | 12 56 | 01 37 | 09 53 | 19 26 | 23 27 |
| 19 | 20 47 | 12 37 | 01 14 | 10 15 | 19 40 | 23 28 |
| 20 | 20 36 | 12 17 | 00 51 | 10 36 | 19 54 | 23 28 |
| 21 | 20 24 | 11 57 | 00 27 | 10 57 | 20 07 | 23 29 |
| 22 | 20 12 | 11 37 | 00 04 | 11 18 | 20 20 | 23 28 |
| 23 | 19 59 | 11 16 | S. 19 | 11 39 | 20 32 | 23 28 |
| 24 | 19 47 | 10 56 | 00 42 | 12 00 | 20 45 | 23 27 |
| 25 | 19 34 | 10 35 | 01 06 | 12 21 | 20 56 | 23 25 |
| 26 | 19 21 | 10 14 | 01 29 | 12 42 | 21 07 | 23 22 |
| 27 | 19 07 | 09 53 | 01 53 | 13 02 | 21 18 | 23 19 |
| 28 | 18 53 | 09 32 | 02 16 | 13 22 | 21 28 | 23 16 |
| 29 | 18 39 | 09 10 | 02 40 | 13 42 | 21 38 | 23 13 |
| 30 | 18 24 | 08 48 | 03 03 | 14 02 | 21 48 | 23 00 |
| 31 | 18 10 | 08 26 | | 14 22 | | 23 04 |

*A Table of the Right Aſcenſion and Declination of ſome of the moſt noted among the fixed Stars for the Year* 1754, *which will ſerve for near* 20 *Years without ſenſible Errors.*

| The Names of the Stars. | Magni. | Right Aſcen. | | Decli-nation. | | N. or S. |
|---|---|---|---|---|---|---|
| | | d. | m. | d. | m | |
| *Algenib* in the flying Horſe's Wing, called alſo *Ala Pegaſi* - - - - - - | 2 | 00 | 10 | 13 | 40 | N |
| *Scheder* in *Caſſiopeia*'s Breaſt | 3 | 06 | 41 | 55 | 03 | N |
| Bright Star in *Aries* - - - | 2 | 28 | 20 | 22 | 09 | N |
| *Mandibula*, or *Mencar*, the Whale's Jaw - - - - | 2 | 42 | 23 | 02 | 06 | N |
| *Algol* in the Head of *Meduſa* | 3 | 43 | 01 | 39 | 53 | N |
| *Aldebaran*, the Bull's Eye | 1 | 65 | 29 | 15 | 55 | N |
| *Capella*, the Goat-Star . - | 1 | 74 | 35 | 45 | 41 | N |
| *Regell*, the bright Foot of *Orion* - - - - - - | 1 | 75 | 28 | 08 | 33 | S |
| *Orion*'s preceding Shoulder | 2 | 77 | 49 | 06 | 04 | N |
| Middlemoſt in *Orion*'s Girdle | 2 | 81 | 01 | 01 | 24 | S |
| Laſt in *Orion*'s Girdle - - | 2 | 82 | 12 | 02 | 07 | S |
| *Orion*'s following Shoulder | 1 | 85 | 31 | 07 | 19 | N |
| *Syrius*, the Dog-Star - - | 1 | 98 | 44 | 16 | 20 | S |
| *Caſtor*'s Head, i. e. the Northermoſt Twin - | 2 | 109 | 41 | 32 | 27 | N |
| *Procyon*, or the little Dog Star - - - - - - | 2 | 111 | 41 | 05 | 54 | N |
| *Hydra*'s Heart - - - - - | 2 | 138 | 56 | 07 | 30 | S |
| *Regulus*, the Lion's Heart - | 1 | 148 | 49 | 13 | 18 | N |
| *Deneb*, the Lion's Tail - | 2 | 174 | 08 | 16 | 06 | N |
| Firſt in the Great Bear's Tail | 3 | 190 | 28 | 21 | 53 | N |
| *Vindemiatrix*, Virgin's North Wing - - - - | 2 | 192 | 53 | 57 | 03 | N |
| *Virgin*'s Spike - - - - - | 1 | 198 | 05 | 09 | 44 | S |
| Middlemoſt in the Great *Bear*'s Tail - - - - | 2 | 198 | 06 | 56 | 23 | N |
| Laſt in the Great *Bear*'s Tail | 2 | 204 | 34 | 50 | 43 | N |
| *Arcturus* - - - - - - | 1 | 211 | 11 | 20 | 39 | N |

| The Names of the Stars. | Magni. | Right Aſcen. | | Decli-nation. | | N. or S. |
|---|---|---|---|---|---|---|
| | | d. | m. | d. | m. | |
| Southern *Balance* - - - | 2 | 219 | 21 | 14 | 53 | S |
| Northern *Crown* - - - | 2 | 231 | 11 | 27 | 40 | N |
| *Antares*, the Scorpion's Heart | 1 | 243 | 37 | 25 | 47 | S |
| *Serpentarius*'s Head - - | 2 | 260 | 58 | 12 | 46 | N |
| *Dragon*'s Head - - - - | 2 | 268 | 00 | 51 | 32 | N |
| *Lucida Lyræ*, in the Harp | 1 | 277 | 21 | 38 | 33 | N |
| *Eagle*, or *Vultur*'s Heart - | 1 | 294 | 46 | 08 | 10 | N |
| *Antinous*'s Hand - - - | 3 | 299 | 54 | 01 | 37 | S |
| *Fomahant*, the Southern Fiſh's Mouth - - - | 1 | 340 | 57 | 31 | 04 | S |
| *Scheat*, in the flying Horſe's Shoulder - - - - | 2 | 343 | 00 | 26 | 36 | N |
| *Marchab*, in the flying Horſe's Neck - - - | 2 | 343 | 09 | 13 | 44 | N |
| *Andromeda*'s Head - - - | 2 | 358 | 58 | 27 | 35 | N |

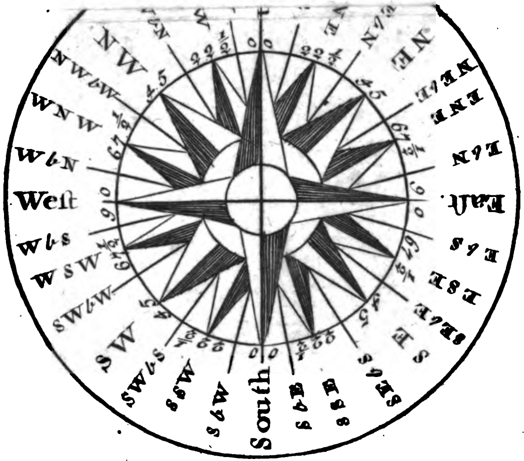
*Note*, In this Edition, which is taken from the fourth publiſhed by the Doctor, there are no Alterations made, except what were neceſſary to adapt the various Parts thereof, particularly the *Tables*, to the *New Style*, and the preſent Time.

☞ Theſe *Tables* will anſwer pretty exactly for every other 50 Years, counting from the Date of the Years here mentioned, *viz.* the *Tables* for 1803, will be the ſame with thoſe for 1703, Allowance being made for the Variation of the Stile; and thoſe for 1853, will be nearly the ſame with the *Tables* here exhibited for the Year 1753. In like Manner the *Tables* for 1754, 1755, 1756, will nearly repreſent the Sun's Declination for the Years 1854, 1855, 1856.

*Tables of the Sun's Right Aſcenſion for every tenth Day of the Years* 1753, 1754, 1755, 1756. *The Sun's Right Aſcenſion for all the intermediate Days may be nearly computed by allowing about four Minutes of an Hour,* i e. *one Degree for every Day.*

| Y. | D. | Jan. | | Feb. | | March | | April | | May | | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | h. | m. | h. | m. | h. | m. | h. | m. | h. | m. | h. | m. |
| 1753. | 1 | 18 | 49 | 20 | 59 | 22 | 51 | 0 | 44 | 2 | 35 | 4 | 38 |
| | 11 | 19 | 33 | 21 | 40 | 23 | 28 | 1 | 20 | 3 | 13 | 5 | 19 |
| | 21 | 20 | 16 | 22 | 20 | 00 | 04 | 1 | 57 | 3 | 53 | 6 | 01 |
| 1754. | 1 | 18 | 48 | 20 | 58 | 22 | 50 | 0 | 43 | 2 | 34 | 4 | 37 |
| | 11 | 19 | 32 | 21 | 39 | 23 | 27 | 1 | 19 | 3 | 12 | 5 | 18 |
| | 21 | 20 | 15 | 22 | 19 | 00 | 03 | 1 | 56 | 3 | 52 | 6 | 00 |
| 1755. | 1 | 18 | 47 | 20 | 57 | 22 | 49 | 0 | 42 | 2 | 33 | 4 | 36 |
| | 11 | 19 | 31 | 21 | 38 | 23 | 26 | 1 | 18 | 3 | 11 | 5 | 17 |
| | 21 | 20 | 14 | 22 | 18 | 00 | 02 | 1 | 55 | 3 | 51 | 5 | 59 |
| 1756. | 1 | 18 | 50 | 21 | 00 | 22 | 52 | 0 | 45 | 2 | 36 | 4 | 39 |
| | 11 | 19 | 34 | 21 | 41 | 23 | 29 | 1 | 21 | 3 | 14 | 5 | 20 |
| | 21 | 20 | 17 | 22 | 21 | 00 | 05 | 1 | 58 | 3 | 54 | 6 | 02 |
| Y. | D. | July | | Aug. | | Sept. | | Oct. | | Nov. | | Dec. | |
| 1753. | 1 | 6 | 42 | 8 | 41 | 10 | 43 | 12 | 31 | 14 | 27 | 16 | 32 |
| | 11 | 7 | 23 | 9 | 22 | 11 | 19 | 13 | 08 | 15 | 08 | 17 | 15 |
| | 21 | 8 | 04 | 10 | 03 | 11 | 55 | 13 | 45 | 15 | 49 | 18 | 00 |
| 1754. | 1 | 6 | 41 | 8 | 40 | 10 | 42 | 12 | 30 | 14 | 26 | 16 | 31 |
| | 11 | 7 | 22 | 9 | 21 | 11 | 18 | 13 | 07 | 15 | 07 | 17 | 14 |
| | 21 | 8 | 03 | 10 | 02 | 11 | 54 | 13 | 44 | 15 | 48 | 17 | 59 |
| 1755. | 1 | 6 | 40 | 8 | 39 | 10 | 41 | 12 | 29 | 14 | 25 | 16 | 30 |
| | 11 | 7 | 21 | 9 | 20 | 11 | 17 | 13 | 06 | 15 | 06 | 17 | 13 |
| | 21 | 8 | 02 | 10 | 01 | 11 | 53 | 13 | 43 | 15 | 47 | 17 | 58 |
| 1756. | 1 | 6 | 43 | 8 | 42 | 10 | 44 | 12 | 32 | 14 | 28 | 16 | 33 |
| | 11 | 7 | 24 | 9 | 23 | 11 | 20 | 13 | 09 | 15 | 09 | 17 | 16 |
| | 21 | 8 | 05 | 10 | 04 | 11 | 56 | 13 | 46 | 15 | 50 | 18 | 01 |

THE END.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67½
90

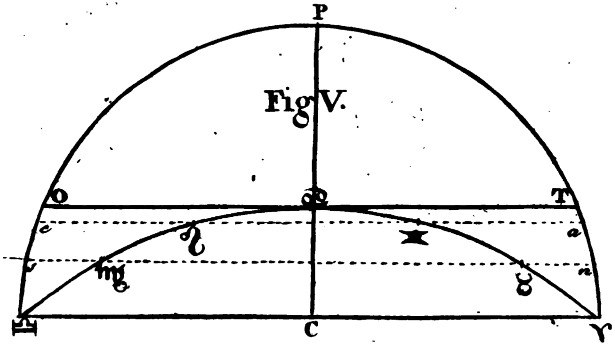
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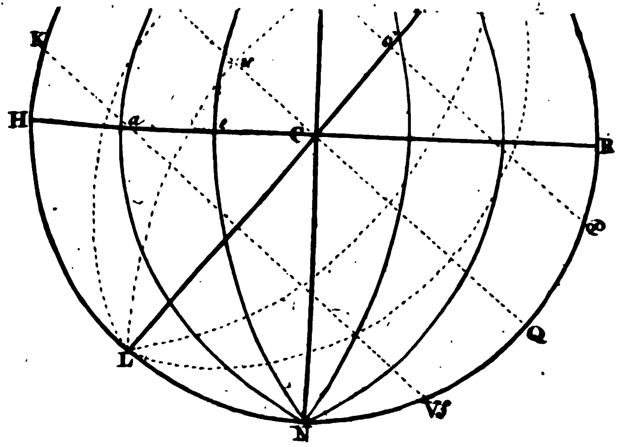
Fig V.



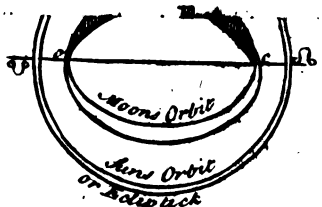
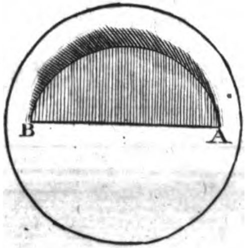


Fig: XI.

Fig: XII.



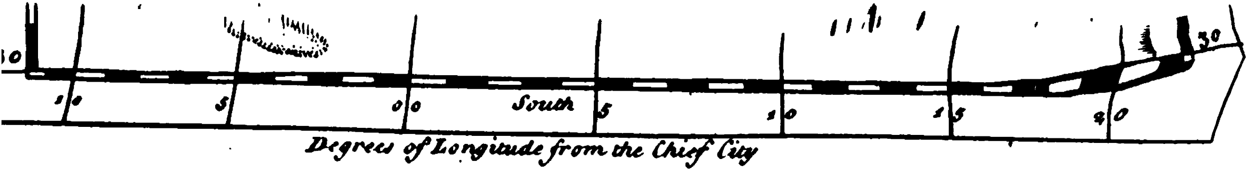


Fig. XIV

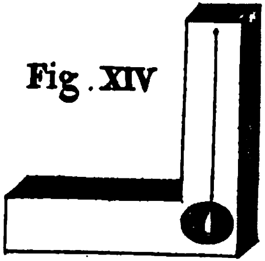


Fig. XV.

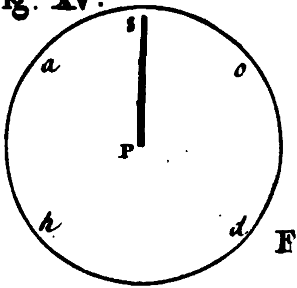


Fig: XVI

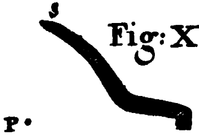
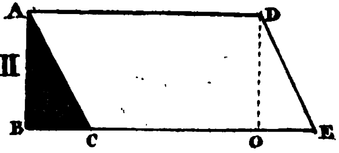
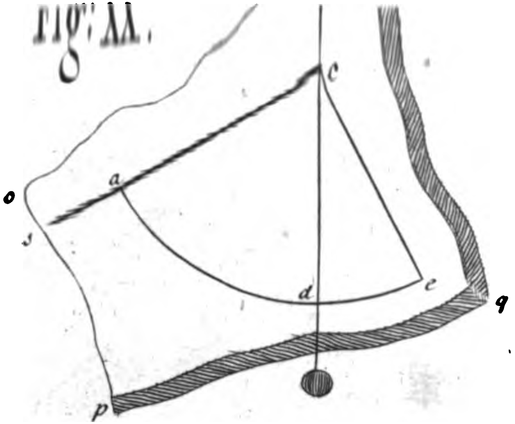


Fig. XVII

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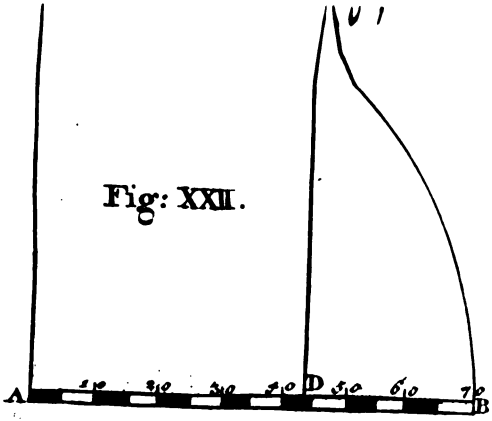
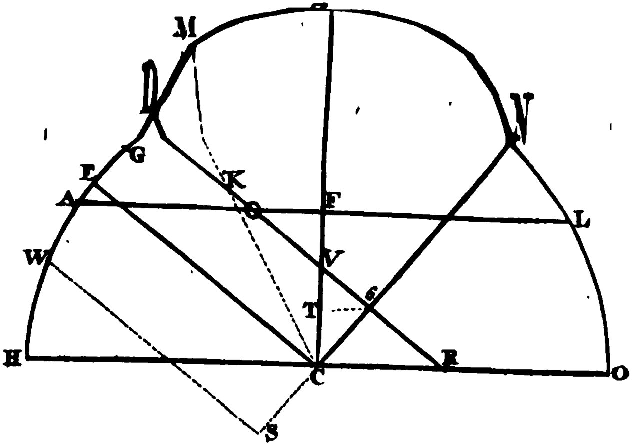
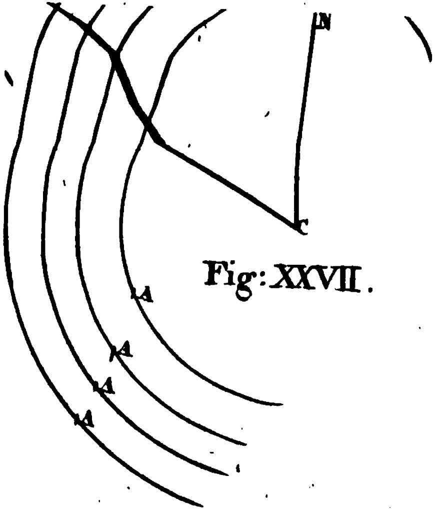


Fig: XXII.





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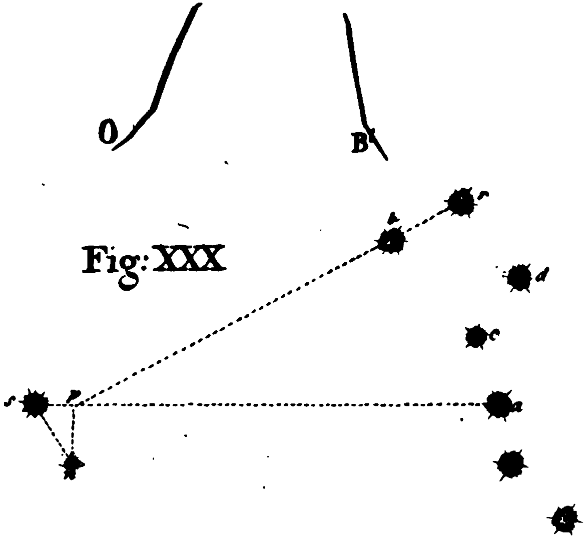

Fig: XXX

HW 2.